



# Repairing the user-bicycle relationship through DIY

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# Repairing the user bicycle relationship through DIY

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# Preface

The reasons for starting this master's thesis were very simple. I love to repair things, and I'm a big fan of bikes. Every day I ride my old vintage race bike to university, and it gives me lots of joy. I've made this bike myself, scavenging parts from everywhere. The frame was a neglected bike that used to be from the grandpa of a roommate. The back wheel I got donated from a friend and bike lover as well, and the new chain I got from another friend with whom I spent my first bike holiday. Together, these parts form a bike that I'm very emotionally attached to. Naturally, keeping this bike in good condition is something that I take pride in.

I've always felt very attached to the products that I use. Products with family stories or things that I got as presents from other people, but also the more mundane things in life. I feel like these objects also deserve my respect in the form of repair and maintenance. Maybe this has come from a place of curiosity about how things work and where they were made. It is this respect for products that I wish more people had, and it is those reasons that lead to repair that I wish to uncover during my thesis.



Throughout my time studying industrial design engineering, I've seen a lot of people struggle with making things. I've worked at the faculty workshop where I taught upcoming industrial designers how to make things. But even here, it feels like we don't have a grip on the material world around us. People are scared to take things apart. They don't feel confident about their skills when it comes to repairing mechanical products.

Therefore, it was only natural for me to pursue a thesis on the topic of DIY. My supervisor's work on *Design-for-DIY* inspired me to rethink the role of the designer. I'd always been fascinated by the maker movement, and I would like to inspire more people to make and mend the world around them. I'm optimistic about what the future has to offer, but I cannot help but see its complications. People feel like they have no time for DIY; it is not valued by our society, and above all, people lack confidence in their own ability to repair things. How could design help to solve these problems?



Photo by Patrick Wetzels

# Definitions & glossary

**Do-It-Yourself (DIY)** – represents a method of building, modifying, or repairing things without the direct aid of experts or professionals.

**Maintenance** – The process of preserving the condition of an object.

**Repair** – Restore (something damaged, faulty or worn) to a good condition.

**Product Care** – All activities initiated by the consumer that lead to the extension of a product's lifetime.

**Product attachment** – The emotional bond that someone has with a product.

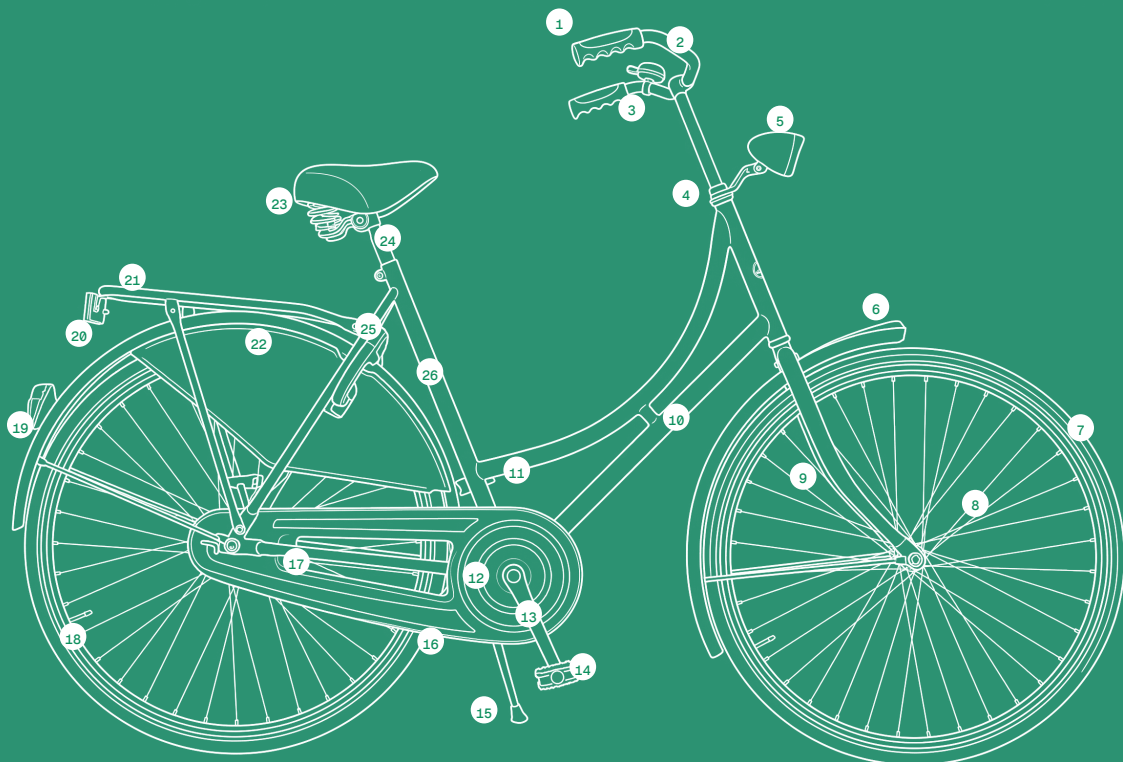
**City bike** – Also referred to as utility bike, or urban bike, is a bike designed for traveling short distances in relatively flat urban areas.

**Omafiets** – A special type of city bike commonly found in the Netherlands, characterized by its step-through frame for easy mounting and dismounting.

**Maker space** – A public space with tools where people can go to work on their own projects.

**Bicycle Kitchen** – A community bicycle shop where people can borrow or rent tools.

**Layman** – A person without professional or specialised knowledge in a particular subject.



1. Handlebar grips  
2. Handlebar  
3. Bell  
4. Headset  
5. Front light  
6. Fender  
7. Tyre  
8. Spokes  
9. Fork

10. Down tube  
11. Top tube  
12. Bottom bracket  
13. Crank  
14. Pedal  
15. Kickstand  
16. Chain guard  
17. Chain stays  
18. Valve

19. Rear light  
20. Reflector  
21. Rack  
22. Coat guard  
23. Saddle  
24. Seat post  
25. Ring lock  
26. Seat post

# Acknowledgements

This project has been all about caring for bicycles, but it wouldn't have been possible with the help, support and care of the people around me.

First I want to thank Freerk and Jan Willem for their support and enthusiasm throughout the project. You allowed me to explore my own process and shape the project how I wanted. Our meetings and discussions always left me excited to continue. Your way of giving feedback always made it easy for me to share my iterations and gave me confidence.

Writing this report was a real challenge for me, and I couldn't have done it without the encouragement of both my dad and Freerk. Thank you for taking the extra time to give me feedback to improve my writing.

Thank you to all my friends for their excitement every time I showed a new prototype. For the coffees, the long discussions and for letting me teach you how to take care of your own bike. Your encouragement helped me to keep going when I felt lost in the project

I also want to thank my colleagues in the workshop for their help, and craftsmanship. Throughout my studies I have become a better maker by looking over your shoulders and by learning from your skill. I Especially want to thank Carlo his jokes and the chocolate milk. You always made me feel at home in the shop.

Finally I want to thank all the people that I've met at Industrial Design and who made me the designer that I am today. But this would all not have been possible without my parents. Thank you for giving me the opportunity and the support to explore the things that motivate me.

# Executive summary

This design project was conducted to explore the potential of *Design-for-DIY* to support product retention of city bikes in the Netherlands. The current situation poses an unsustainable relationship with bicycles, where they are left to decay until they hold no functional value anymore.

Bicycle owners don't care for their bikes because they are valued purely for their functionality and because it is easy to get cheap replacements.

In order to increase retention, it is essential to keep the value of the bike high before repair is needed. We could focus on repair, but people don't feel motivated to repair things that they don't care about.

Therefore, we should design for emotional value through product attachment. Within the field of *Design-for-DIY*, this can be achieved through maintenance and making. I propose that in both cases, the pleasure of the process is a determining factor. Maintenance and making only lead to product attachment when it is pleasurable. Repair was found to be inherently unpleasurable for laymen because of its unpredictability, while the making process can be controlled by the designer to adjust to the skill level of the maker.

This project combines the benefits of making with those of maintenance by providing a way to replace broken bike parts with DIY alternatives. In this way, the self-made parts will make the bike more unique and lead to emotional value in the form of product attachment. Maintenance can simultaneously lead to social value, because the result becomes visible. And finally, the concept shows the potential to increase repair confidence for future repairs.

## **The concept: UpKeep bicycles**

The final concept is an open source family of eight bicycle parts focused on reducing the feeling of degradation of the bike. Contrary to DIY project this concept highlights the importance of making together to build confidence and to create a pleasurable experience.

Therefore, the concept should be hosted in bike stores, makerspaces and bicycle kitchens around the Netherlands. To create awareness, a website was made with all the relevant resources. Customers can use it to find a workshop nearby, and it also provides a platform for workshop hosts and the rest of the community to share ideas and continue development of the bicycle parts after this project.

The project creates a starting point for future development by providing insights about creating pleasure in the making process, summarised in a set of guidelines for the community.

Three parts were prototyped (fender, bell and chain guard) during this project, showing the feasibility of making bicycle parts that are of similar quality to industrially produced ones. A workshop was designed around making a chain guard that was tested with 7 participants. The workshop was found to be highly pleasurable and led to an increase in bicycle attachment, and repair confidence. Showing the potential for this concept to increase bicycle retention.



SAFETY GLASSES  
INSIDE

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# Introduction

## Moving towards convenience

In the Netherlands, bicycles have become so common that they have lost most of their value as personal possessions. What in many cultures is still seen as an object of care and pride has turned into something that is purely valued for its functionality. With 1.3 bikes per citizen in the Netherlands (Rai & BOVAG, 2025), it seems a saturation point has been reached where bikes no longer hold the same value. Every year, around 350,000 neglected and abandoned bikes are picked up by municipal services (Meines, 2024). While some useful parts get a new life, most frames move to recycling, showing a widespread culture of disposability.

Most of these bikes are not beyond repair; they suffer from a lack of maintenance. Bikes show signs of wear, well before they need to be maintained. Users tend to be unaware of these signs or simply ignore them. And because most city bikes are kept outside, they slowly decay to a point where they hold no functional or emotional value. This neglect seems to reveal how our relationship with everyday objects has changed.

As a response to this trend, service-based models like Swapfiets have increased in popularity. A bike is seen as a functional object that needs to fulfil its purpose all the time, and waiting for a bike repair or even doing the repair yourself is seen as a hassle. Changing a tyre is now a matter of calling the repair service, and the problem will be solved for you. The user is disconnected from all the responsibilities that come with owning an object, while there is a lot of gratification and pride that can be gained by taking care of our own products.

This drive for convenience is common throughout society, detaching us from the products we own. I believe that in order to have a more meaningful and long-lasting relationship with products, taking care of things should be our own responsibility.

## Circular economy

Bikes are generally seen as a sustainable mode of transport. They are far less material and energy-intensive to manufacture than, for example, cars, and they don't have any emissions during use. For these reasons, large urban cities are investing in cycle-friendly roads and are banning cars from the city centres. A larger adaptation of bicycles in urban areas is a positive development, but it will also increase the urgency to find a solution for neglected and discarded bikes.

From an ethical standpoint, designers have the obligation to consider what happens to products when they get discarded. This is the case for all products, but especially for commodities like bicycles in the Netherlands, small changes can have a considerable impact on the environment.

The Ellen MacArthur Foundation (2013) poses a model for looking at waste more holistically and suggests that we should move to a circular economy. Within the techno cycle, different loops exist: maintain, reuse, refurbish and recycle (see butterfly diagram below). The bigger the loop, the bigger the negative impact. In essence, the Circular economy proposes to keep our products in their highest value. Maintenance and repair are the most powerful tools against climate change, extending the life of products and postponing disposal.

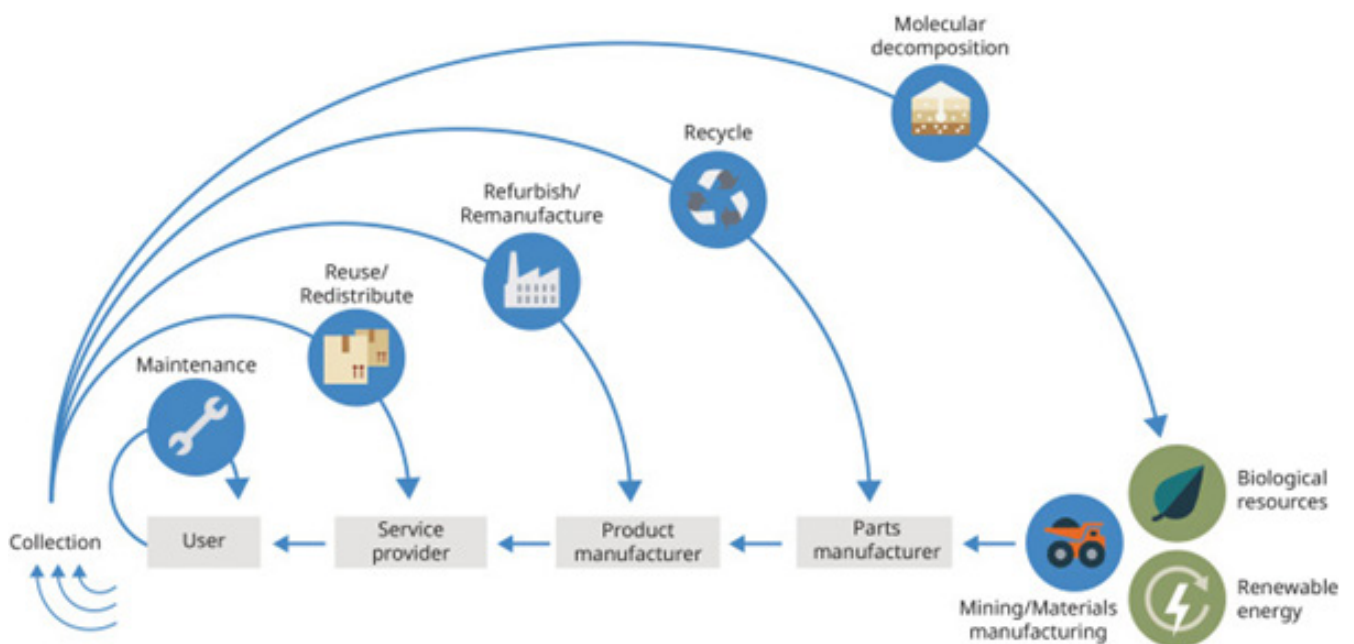


Figure 1: Circular economy butterfly diagram - The technical cycle (Ellen MacArthur Foundation, 2019)

Many products are discarded prematurely, not because they no longer function, but because they are designed in ways that make repair difficult or undesirable and because visible signs of wear often diminish the users' emotional connection to their belongings. Despite their long lifespans and relevance, bikes are often treated as replaceable commodities. If we are to transition toward a more sustainable future, designers need to start considering user behaviour throughout the entire product life cycle.

## Looking at city bikes from a DIY perspective

This report explores the effect that DIY can have on sustainable bicycle behaviour. Do-It-Yourself or DIY is described as 'the method of building, modifying, or repairing things without the direct aid of experts or professionals' (Bonvoisin et al., 2017). DIY is a countermovement that goes against the fabric of our consumer society. It places the consumer between production and consumption, whereas they have been mostly separated since the start of the industrial revolution. DIY inspires people to explore, experiment and understand the material world around them and gives them the tools and skills to make it their own.

### How DIY is gaining popularity

Everywhere, there are Makerspaces and Fab(rication) labs popping up in big cities. These are spaces where people can come together in communities to create together. The rise of these spaces can be attributed to the accessibility of digital fabrication technologies like 3D-printing, laser cutting and the software used to control them. DIY has become simpler, less skill-focused and easier to share. Consumers can create high-quality parts from the comfort of their homes (Anderson, 2010).

Sharing has been a key term in this development. Similar to open source software, where complicated pieces of code are shared for others to use, the maker community is following this trend related to hardware. On platforms such as Thingiverse, YouTube, and Instructables, people can share easy-to-follow instructions for the things they have built. This development, which has been enabled by the internet, has made 'making' more accessible. Where the knowledge needed to make things was historically reserved for those with years of experience and craftsmanship, new technologies seem to have enabled an easier, more approachable way of making. On YouTube, people can share their projects and experiences about making, repairing and mending things.

Additionally, consumers have become more aware of the environmental impact that their consumption behaviour has on the environment (Euromonitor International, 2025). Companies have moved their production overseas, and with the increased complexity of products, they have become more difficult to repair. The European 'right-to-repair' movement shows that there is an urge from consumers to consume more sustainably. DIY solves this by closing the distance between consumption and production and teaching consumers about the function of products, allowing them to take care of their own. Given the popularisation of DIY, this seems like a great time to explore the effects that Design-for-DIY can have on our product relationships.



Photo by Patrick Wetzels

# Project goal

The goal of this project is to make the use of city bikes in the Netherlands more sustainable. It was inspired by the many neglected bikes that can be found on Dutch streets. These bikes decay to a point where they no longer hold any value, which ultimately leads to them being discarded. Product designers often consider sustainability before and after use of the product. In this project, I will focus on understanding the unsustainable user-bicycle relationship and apply methods from the field of *Design-for-DIY* to try to strengthen this relationship.

I hope to create a new awareness for where things come from, how they were made and how they function. I believe this can foster a new appreciation for products, which is needed for longer-lasting human product relationships.

## Research questions

The following research questions provided the structure for the analysis phase of the project. They help to understand the field of *Design-for-DIY*, its benefits, and how they can be applied to the context of urban bicycles. The main research question is:

### **How can Design-for-DIY support product retention and extend the lifespan of city bikes in the Netherlands?**

This question is divided into 5 sub-questions that are individually addressed in the following chapters:

1. How sustainable is the use of bicycles in the Netherlands?
2. How can retention be supported by *Design-for-DIY*?
3. What are the barriers and motivators that influence the maintenance process?
4. How does engaging in making and maintenance change the user-bicycle relationship?
5. What design opportunities emerge to support DIY engagement and product retention for city bikes?

## Research process

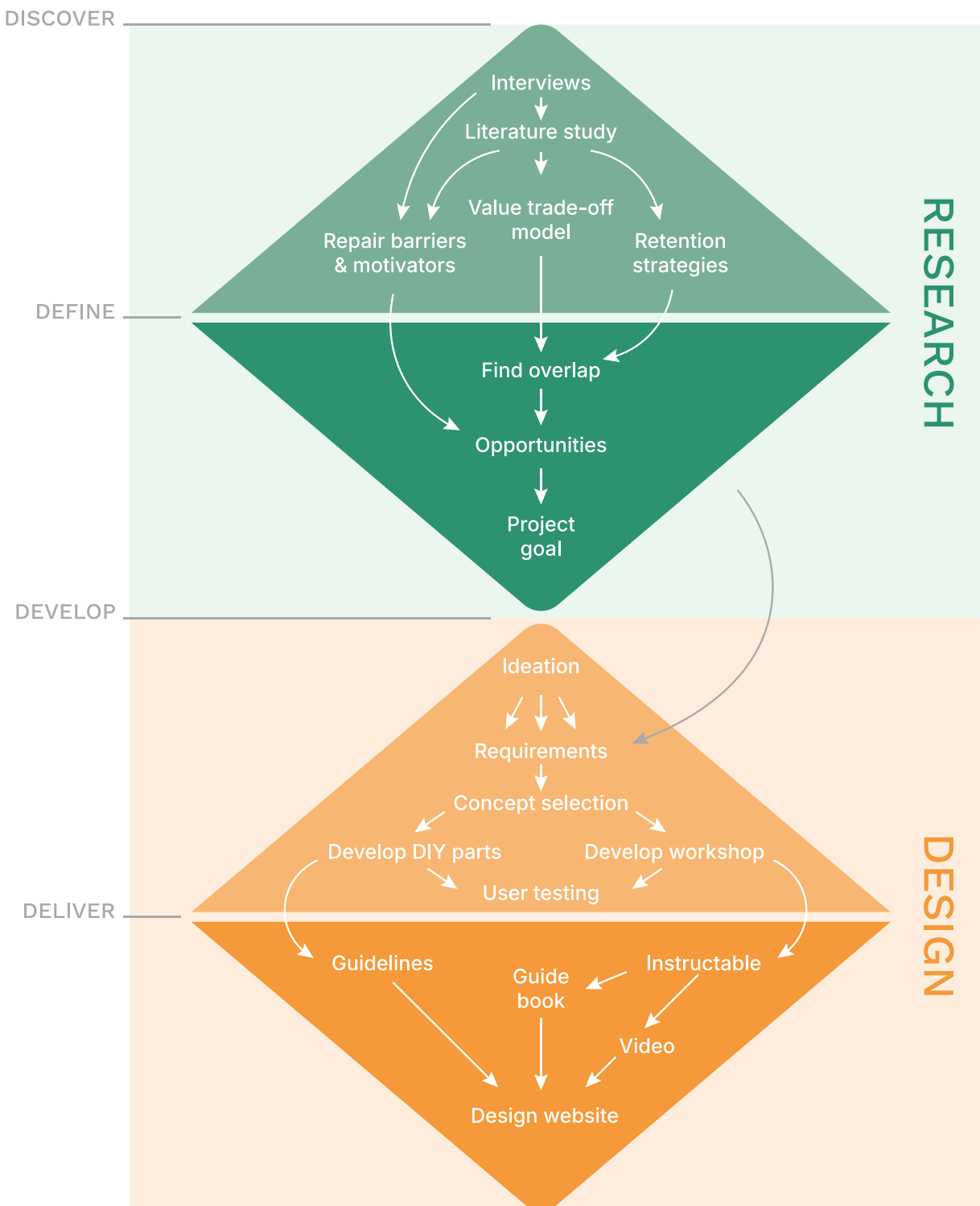
The research was based on the work of my supervisor, Jan-Willem Hoftijzer (2024). His dissertation on *Design-for-DIY* is what inspired me to work on this project. He clearly addresses our unsustainable product relationship and describes *Design-for-DIY* as a possible solution space. I used his research as a starting point for understanding the user-bicycle relationship.

Early on in the process, I read the dissertation by Ackermann (2020), a PHD from our faculty, that then became essential in my understanding of the topic. Her work focuses on taking care of products, which is often neglected in sustainability literature. It describes products from the perspective of the value that they offer to us, emphasising that they deserve our care. This resonated with me because, contrary to other circular strategies, where products are kept in the loop after they are broken, Ackermann emphasises the things we can do as designers during the use phase. The paper, *Too good to go?* (van den Berge et al., 2021), referred to by Ackermann, introduced the concept of product retention to me and formed the backbone of the analysis phase.

# Approach

The approach for his project was based on the double diamond method. This method divides the design process into four categories: Discover, Define, Develop and Deliver. The first two form the analysis or research phase of this project. Understanding the problem and defining where to focus my attention. The research part consists of chapters 1 to 5. After this phase, multiple ideas were developed. A research by design approach was used to test the feasibility of the chosen concept vision. This is presented in chapters 6 to 10. To conclude, the final result of this thesis is presented and reflected upon during the deliver phase in chapters 11 to 15.

The image below shows a more detailed overview of the steps that were taken in each phase.



# RESEARCH



# 1 How sustainable is the use of bicycles in the Netherlands?

Bikes, of themselves, are a very sustainable mode of transport. They cause no harm to the environment in the form of pollution during use. But during production, the bikes do pollute the environment through the mining of materials, the production process and transportation. This means that bikes can be made more sustainable by extending the life of the product. This chapter explores the current use of bicycles and aims to give an evaluation of its sustainability.

## 1.1 The Dutch city bike

The research concerns the Dutch city bike. A city bike can be categorised based on two things, its design (appearance and characteristics) and its use case. It is important to define what is meant by a city bike to have a clear focus for the rest of the research. This chapter starts by giving a clear definition of the Dutch city bike and continues by dissecting one of these bikes completely to the last nut and bolt.

In terms of design, bicycles always consist of the following parts: A frame, wheels, handlebars, pedals, a drivetrain, a saddle, and brakes. Usually, the different types of bikes can be distinguished by the build-up of these components, for example, the weight and material used, but also by additional parts. City bikes have some parts that make them specifically suited for urban use: a front or rear rack to carry goods, fenders to protect the user in case of rain, a chain guard to protect your clothes and lights to provide visibility while riding in traffic.

The *omafiets* is the most common Dutch city bike and has become synonymous with the Dutch cycling culture. The bike is characterised by having pedal brakes, an upright frame position and usually comes without gears or with an internal hub gear. The bike is not praised for its design aesthetic but for its functionality and low price. Because of its robust design, it can survive long periods with low maintenance. The picture below shows two bikes made by Gazelle.



Figure 2: Gazelle city bikes - Tour Populaire C3 (left), Chamonix S11 (right)

The one on the left started production around 1955, and the bike on the right is the latest city bike from the same brand. The *omafiets* is still being produced as of today, and even the company Swapfiets has copied most of this traditional design for their bike-as-a-service system.

The city bike has seen many improvements over the years in terms of performance and comfort. The frame is usually made of aluminium instead of steel. The chain is sometimes replaced with a belt that is more maintenance-free and is connected with an internal gear hub that can have up to 11 speeds instead of 3. There is suspension in both the seat post and the front fork and the saddle is made out of gel. This bike has LED lights that are connected with an integrated dynamo and has disc brakes instead of a drum brake. Even though these technological advancements have improved the city bike, they are still not commonly found on the streets. Likely, because all these improvements don't really have a benefit when it comes to their intended use case, and this makes them more valuable and increases the risk of being stolen.

City bikes or utility bikes are commonly used for commuting to work, school or for travelling over short distances within a city. Any bike can be used for this purpose, but the features mentioned above make it more suited for city use. For this reason, the design of the bike is used as the main differentiator to describe the target bicycle of this project.

### Taking apart a city bike

As a starting point for this research, an old neglected city bike was completely disassembled. This was mostly to familiarise myself with every part of the bike and to understand its inner workings, but also to see where parts wear, due to extensive use or simply being exposed to the elements.

The bike here is not chosen for any specific reason except that it has some very common characteristics for a Dutch city bike (see previous paragraph). This model has an unusual frame, being quite small, made out of aluminium and because of its shape. These things can be neglected when looking at the rest of the bike.

Most older bikes show a history of repair. Multiple different fasteners were used to attach the fenders, and underneath the rubber handle grips, tape was used so that they wouldn't come off. This is a perfect example of how every bicycle tells a story through the repairs that have been done to it.

Overall, it took 2 days to take the whole bike apart without a manual. Most of the time was used to find the right tools, loosen rusted bolts and figure out how things were attached. This gave me many ideas on how to improve the design of a bicycle, which can be found in Appendix 1. In total, this bike had 489 parts, counting every component that could be taken apart using hand tools. They were laid out on the floor of the workshop using a method called 'knolling'. The objects are grouped and laid out on a flat surface to create an overview.

This shows the hidden complexity of something as simple as a bicycle. It is clear that a product with this many moving parts requires attention from its user

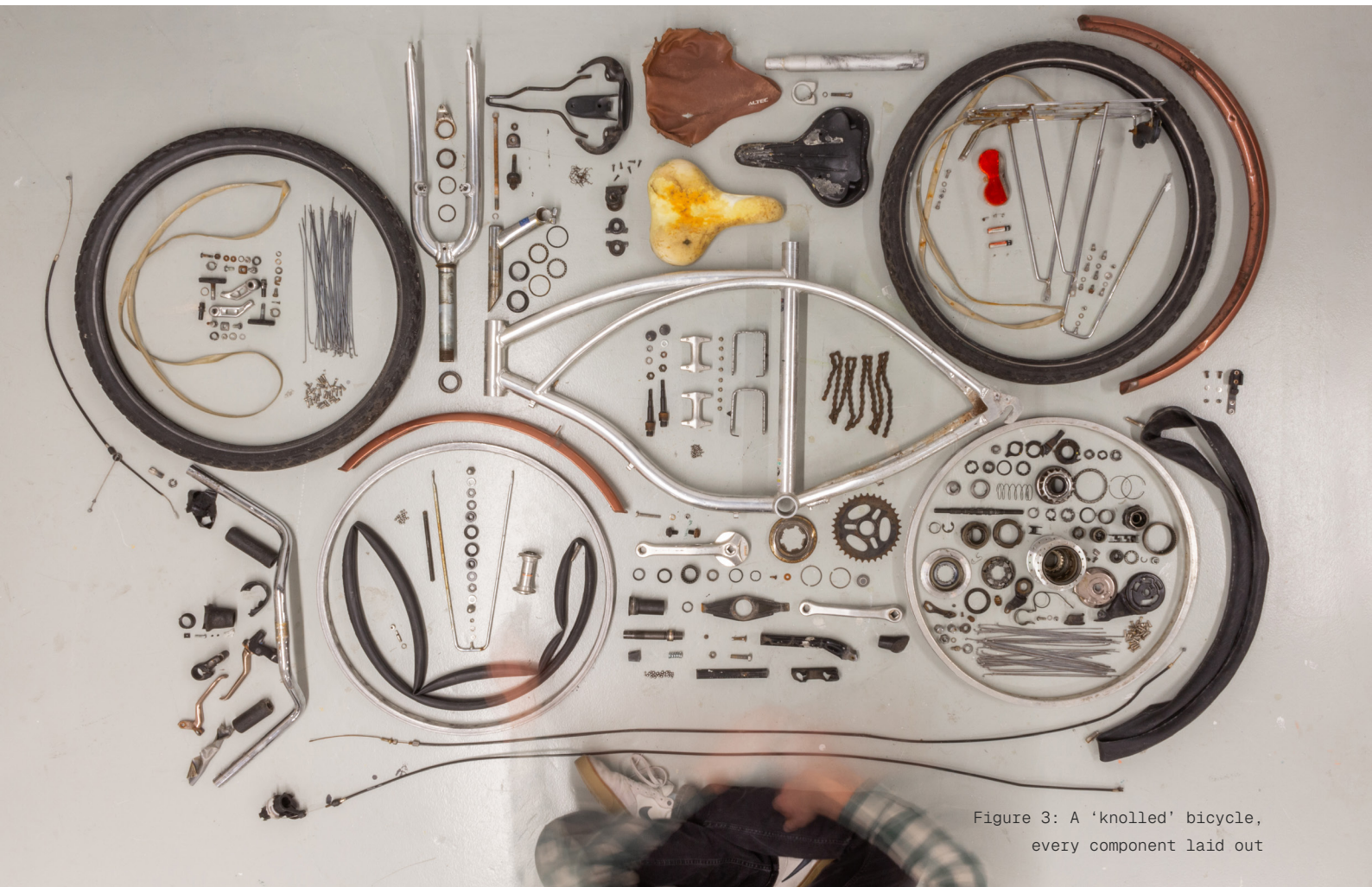


Figure 3: A 'knolled' bicycle, every component laid out

## 1.2 Life of a bicycle

A Dutch city bike lives a very lonely and uncertain life. From the day it was bought by its owner to the day it gets recycled to serve as materials for something new, it goes through a lot of different stages. But even before it gets to the owner, it has likely led a life already. Most city bikes are bought on the second-hand market, from a bicycle store or through an online marketplace. When it ends up in the hands of the owner, the bike lives a life fulfilling its purpose every single day. Transporting you to work or school, helping to buy groceries and bringing you to social gatherings. It is part of everyday life, which can make it easy to forget it is even there.

Bikes accumulate in racks on the streets, where they feel like clutter and support the notion that they are garbage. Here they are exposed to all sorts of external factors, like the weather. Rain can creep into all the corners where it starts to corrode.

There are many human factors influencing the life of the bike as well. When we are rushed, we tend not to be as mindful. We push away bikes to make space, often scratching and knocking over other bikes in the process. And because we expect others to treat our bikes the same way, they end up lying on the ground aimlessly waiting to be picked up by their owner. Sometimes they even get pushed into the canals, as can be seen in Figure 4.



Figure 4: Bike depot Amsterdam West (ANP KOEN SUYK © picture: ANP) ▼

Municipalities often remove bikes from rack and the sidewalks in an attempt to contain the inevitable chaos. Bikes that are misplaced by their owner can immediately be removed and brought to a depot outside of the city. But they also try to find the bike 'wrecks'. Understandably, these are bikes that are missing vital parts, like a saddle or have a flat tyre. But bikes that are used daily also run the risk of being picked up. A sagging chain or a rusting fender gives the impression that the bike doesn't get used. If the owner doesn't notice it in time, the bike will be picked up and brought to a depot where it will share its fate with many other bikes. In the Netherlands alone, upwards of 350,000 bikes are collected each year (Meines, 2024). Around a quarter of all the bikes are collected by the owner, but because of the cost and the effort it takes to retrieve it, most people end up replacing them with a new or used bike (Het Parool, 2024).

As mentioned before, bikes get scratches, the frame starts rusting, and the chain starts rattling. It is this evolution that Crang calls “the negative unbecoming of things” (Crang, 2012). Bikes slowly age until they brake. They no longer fulfil their intended purpose, and they become things. Bill Brown (2001) describes it beautifully in his ‘thing theory’:

“We begin to confront the thingness of objects when they stop working for us: when the drill breaks, when the car stalls, when the window gets filthy [...] The story of objects asserting themselves as things, then, is the story of a changed relationship to the human subject and thus the story of how the thing really names less an object than a particular subject-object relation.

The thingness of an object can also become apparent when it partly malfunctions. For example, a chain that falls off every time you go over a slight bump or a brake that doesn’t work anymore. It makes us painfully aware of the functions of the different components and assemblies that make up the bike. We even change our behaviour based on the state of the bike, changing our route or avoiding busy intersections. A friend mentioned that he brought a screwdriver everywhere he went to be able to get his chain back on without getting his hands dirty. He even understood how to adjust it, but he never took the time to change it.

Products go through different stages of life as Kopytoff describes (1988, p. 90) in his essay on the process of commoditization. Products have social lives as well that can be described in the biography of an object. He challenges us to see objects not just in the context of a market with a certain monetary value, but to look at the social and cultural aspects of objects.



Figure 5: A pile of bicycles fished out of the canal in Delft ▶

The ‘biography of things’ as understood by Kopytoff looks at the maker of the object, its use and eventually how it will be disposed of. Products might mean different things to different people and within different societies. They are not bound to one conception or idea. Similarly, products can move in and out of commodity status. Commodities are objects that we can assign a market value to, but when an object gets sentimental or emotional value they can be decommoditized. Bikes are generally considered commodities in Dutch culture. And although these patterns are difficult to change, designers have the opportunity to change how we perceive and relate to our products, even commodities.

## 1.3 Different types of bikes and our relationships with them

City bikes are just one of the many categories of bicycles, and not all bikes are taken care of in the same way. This section explores different bicycle types and gives reasons for the different user-bicycle relationships.

### Race bikes

Race bikes, unlike city bikes, are very expensive. They are part of people's leisure time instead of a purely functional object. Race bikes have a social component because they are part of a hobby and a sport, and there is a whole community of people talking about the product itself. Sport cyclists upgrade their bikes because they want to have the latest features. After a ride, the bike is cleaned, the chain is lubricated, and it is safely stored away for the next opportunity for use. In this context, bicycle care is something that people take pride in.



Figure 6: High end race bike made by Focus (wielrenner.eu) ▲

### OV-bike

The *OV-bike* is part of a bike service system implemented by the Dutch Railway company. It is a rental bike that you can use to make the last mile from the train station to your final destination. After use, the bikes have to be returned to their original station, and people pay per day.



Figure 7: OV-bike (NRC) ▲

These bikes are incredibly robust and made for intensive use. Because the company keeps ownership, the product is always properly maintained, and issues are addressed immediately. However, this business model doesn't allow customers to build a relationship with the product. Bicycles become even more commoditised. Cycling is becoming a service that you can make use of.

### Swapfiets

Similar to the *OV-bike*, Swapfiets is a service model. The bikes are still owned by Swapfiets, but when you get a subscription, you get assigned a single bike. Maintenance is incorporated in the price, because it is in the best interest of the company to make the bikes last as long as possible. What I find interesting is that these bikes are still often badly maintained. This can be attributed to many things, but a possible cause is a bad product relationship. People who use a Swapfiets are less careful with their product because they don't feel ownership over the product (Brondijk et al., z.d.). Similarly, the bikes are often locked using only a ring-lock, because a replacement is immediately on its way. This shows that even when barriers towards product care are reduced to a minimum, it is not people's natural behaviour to take care of their products.



Figure 8: Swapfiets (fietzersbond) ▲

## 1.4 Market

On average, every Dutch person has approximately 1.3 bikes. Still, in 2024, 858.000 new bikes were sold in the Netherlands. Of which, a fifth consisted of non-electric city bikes (*Mobiliteit in Cijfers Tweewielers 2025 - 2026*, z.d.). A similar report stated that in 2023, around 180.000 new city bikes were sold compared to almost 160.000 used ones (Rai & BOVAG, 2025).

The second-hand market for city bikes is of a similar size to that of new bicycles, so it is important to understand where these bikes come from. Bicycle shops make up the largest part of these sales. Trade-in policies are used to convince people to buy a new bike. Old city bikes are then repaired and sold on the second-hand market. Recently, the popularisation of electric bikes has led many people to trade in their old city bikes.

But bikes are also often stolen (Ypma, 2025), repainted and sold through non-official channels like Facebook Marketplace and Marktplaats. The bike that is most at risk is the black utility bike. Especially the bikes that are in good condition are vulnerable to theft. Companies like Batavus have tried to address theft by giving their bike a unique code. This 'Personal Bike' is less likely to get stolen on the streets, because it is difficult to remove the bike's unique identifier. Theft influences bicycle care in two ways: how much we are willing to invest in our bikes, while simultaneously lowering the price of replacement.



Figure 9: Batavus personal bike (fietsstunt.nl)

By comparing sales figures to the total size of the bicycle park over six years (2019-2024), an estimate can be made of the number of bikes discarded or abandoned each year. Based on the numbers by the RAI, the national interest group for the Dutch mobility sector, approximately 700,000 bikes are disposed of yearly (*Mobiliteit in Cijfers Tweewielers 2025 - 2026*, z.d.). This number is similar to the yearly sales, which is logical given the steady state of the bicycle park.

## 1.5 Industry

In order to get a better understanding of the bicycle industry, I had an interview with Ing. Alagourie, ex lead design at Gazelle. My questions were directed towards the sustainability of the industry and design for repair in particular. Although it may seem like the market doesn't evolve much, the industry is very focused on innovation and following market trends. Especially big brands like Gazelle, Batavus and Stella bring out new models every year to incentivise people to buy a new bicycle.

Designers look for incremental ways to improve performance and make the bikes more aesthetically appealing. Within this philosophy, design for repair or even self-repair was never a big concern for manufacturers, according to Alagourie. Spare parts are available for bicycle shops, but are more difficult to get for consumers, and disassembly often requires proprietary tools. This is especially common in the race and mountain bike segment, but this trend may trickle down to the city bike market in the future (Szto & Wilson, 2023). Design for ease of disassembly has never been a big concern, because it is more beneficial for the manufacturer if the repair is performed by a trained professional.

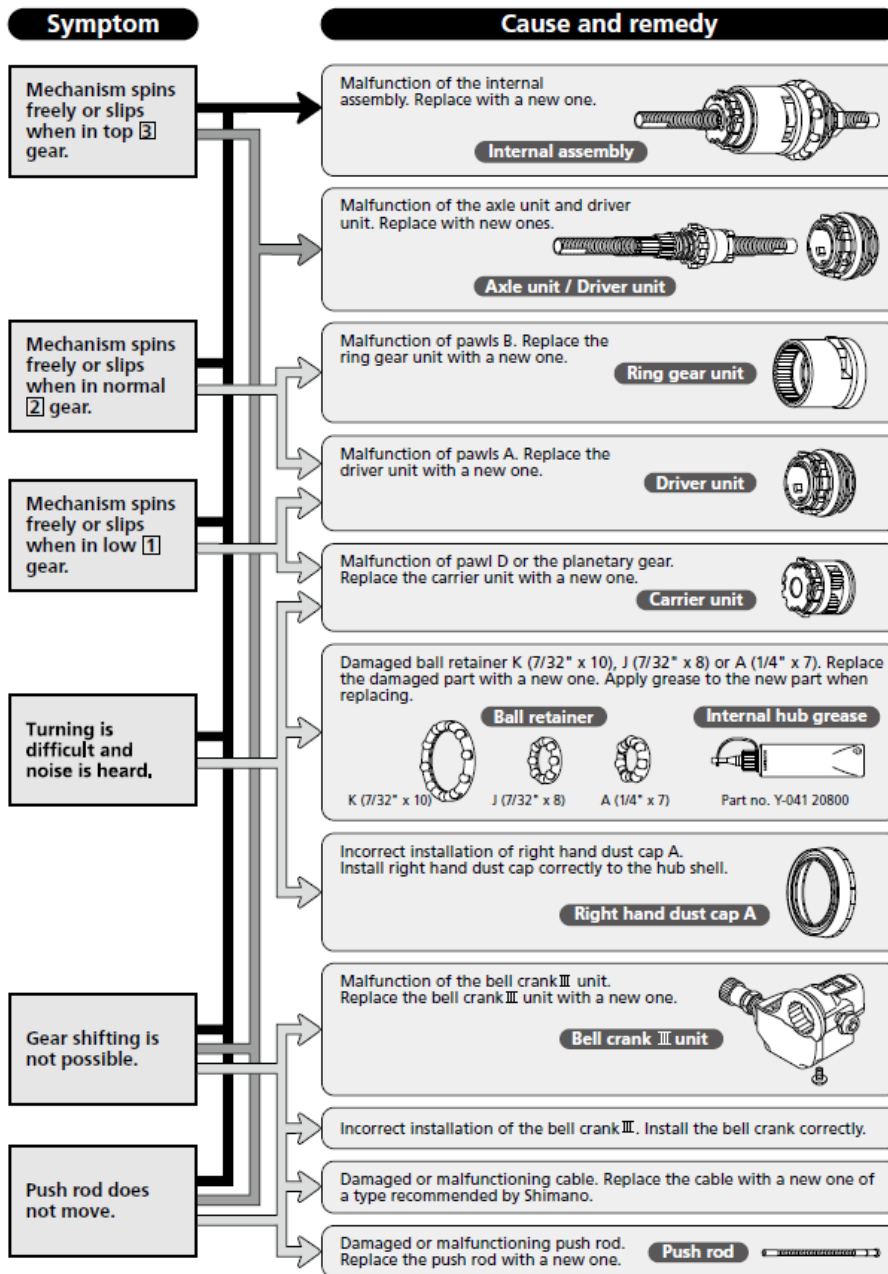


Figure 10: Troubleshooting flow chart for Nexus 3 internal hub gear (Shimano Nexus 3 Manual, 2022)

There are exceptions; in Figure 10, a flow chart can be found for repairing a 3-speed hub gear from Shimano. Although probably made for mechanics, it can provide everyone with the information needed to repair their internal gear hub. However, the newer 7-speed hub has gotten so complicated that it is not possible to repair, showing how innovation can make bikes less repairable.



Figure 11: Headlight integration - Classic headlight (Bobbin bikes), modern Gazelle fender vision (Design)

## Roetz

Roetz is a Dutch company that started by refurbishing old city bikes and selling them as new. When electric bikes started to gain popularity, they wanted to enter this market, but in a different way. They recently introduced the Lifecycle, a bike that is designed to last a lifetime. They have designed the bike in such a way that all the parts are easy to repair and replace. The front and rear wheel for example, are the same and can be replaced within seconds. Many of the parts are modular and can easily be replaced or upgraded. For electric bikes, especially the motor and the battery, undergo big developments, so being able to upgrade allows customers to use the same bike frame for longer. This concept shows the value of the frame and that there are opportunities for sustainable innovation in the cycling industry.



Figure 12: Roetz Life Cycle - circular e-bike (Roetz)

## 1.6 Repair practices

Bicycles are already considered relatively easy to repair in the repair literature (Batterbury & Dant, 2019). It is maybe because of this reason that the cycling industry has not seen any changes in terms of reparability in years. Most of the day-to-day repairs can be done at home, and when the repair becomes too complicated, or we don't have time in our busy lives to do the repair ourselves, we can rely on a big network of bike repair shops. Because of this reason, I wanted to know which repairs are done by laymen and which are done by professionals.

### 1.6.1 DIY bicycle repair

Using the open source database with 4700 datapoints from Dutch Repair Cafés, I was able to find the most frequent repairs (*Dashboard Repairmonitor*, n.d.). These were also ranked on their reparability by experienced volunteers (high, meaning easy to repair). Surprisingly, in most cases, people went to a Repair Café to do relatively simple repairs like patching or replacing an inner tube. This shows that bicycle repair may not be as easy as the literature suggests. Additionally, this group of common repairs were all repairs that prevented people from using their bikes. A flat tyre, or a badly tensioned chain make it impossible to use the bike. This shows that users were only willing to take action when it was strictly necessary.

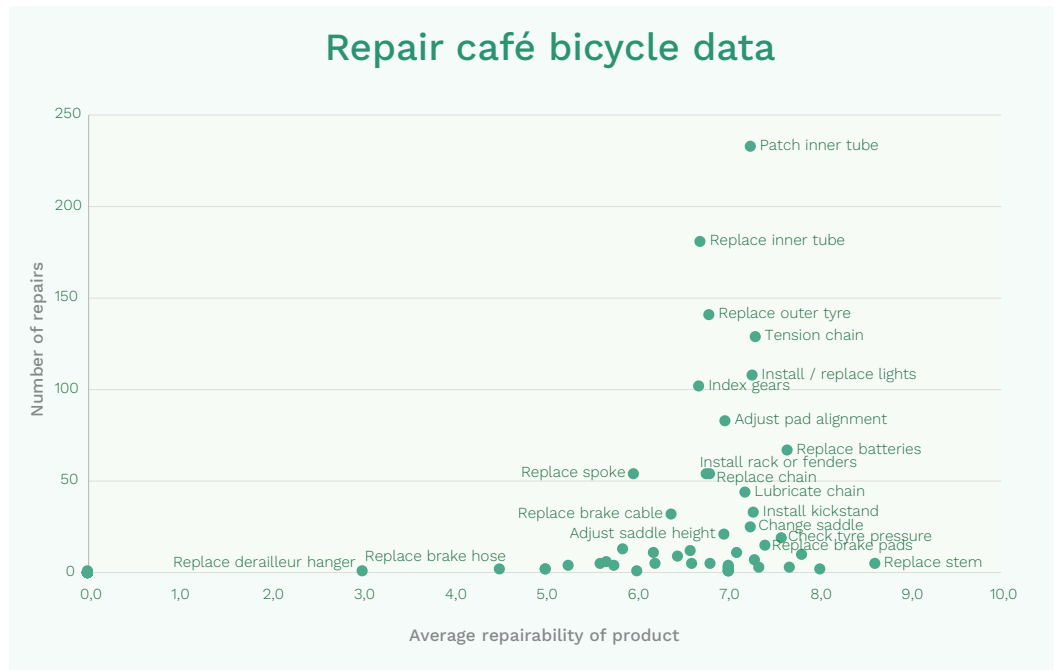


Figure 13: Repair café data - The most common repairs and their average repairability

### 1.6.2 Bicycle repair shops

Bicycle repair shops are everywhere in the Netherlands. Usually, bike repair happens inside a retail store. New bikes are always sold with mandatory maintenance. The first maintenance is included in the price and required by the manufacturer, and further maintenance is sold with the bike to extend the margin on sales. There are also dedicated bike shops. These often sell bikes that have been refurbished or repaired for a discounted price as well, but without the factory warranty that is provided with a new bike.

In the Netherlands, you can go to school to specialise in bicycle repair. There, you can learn about repair and maintenance and get certified. According to Martijn Hoek, manager of education at the Roemer Visscher College in The Hague, bike repair has become less specialised. Repair shops used to be able to do complicated things like building wheels or repairing internal hubs, but it is not part of the curriculum anymore. Labour has become too expensive, he says. The price of a new internal hub is always lower than the labour needed to repair it.

This project emphasises the role of the layman in the repair process, which could potentially come at the cost of bike shops. However, given that there are so many different attitudes towards DIY, there will always be a place for professionals.

### 1.6.3 Bicycle kitchens

Bicycle kitchens are best described as makerspaces for working on bicycles (Bradley, 2018). They have become popular in Western-European countries, but the Netherlands only counts three in total (Demkes, 2024). In the first place, these 'kitchens' offer a cheaper alternative to professional repair. But the goal is broader. They are enablers to give people the skills and the confidence to do their own repairs. In a broader sense, this is part of the democratisation of technology. By teaching people the skills to take care of their own repairs instead of doing it for them, people get more autonomy. Bicycle kitchens show the importance of self-repair for the environment and as a way to strengthen the relationship with our products.



Figure 14: Bicycle kitchen at the University of Amsterdam (SEBASTIANBIKE, 2024)

## 1.7 Conclusion

Around 800.000 bikes are sold each year in the Netherlands, of which 340.000 are city bikes. Because the bicycle park has reached a steady state, a similar number of bikes are either discarded or abandoned each year. Bicycles are inherently sustainable products, but when they are recycled, they lose their value. The solution in terms of sustainability lies in the use phase of the product.

Bicycles are often neglected, left in the streets, exposed to the elements and careless handling. They are stolen, left to rust, and collected by municipalities because sagging chains and rusting fenders suggest that they have been abandoned. When bikes get picked up by municipality services, the inconvenience of retrieving the old bike often leads people to buy a new or second-hand one instead. This is a sign of our broken relationship with bicycles, and it doesn't show a sustainable way forward. Repair data shows that people are only willing to repair when it is strictly necessary. This is reinforced by the industry, which prioritises innovation and aesthetics over repairability and by a large second-hand market that strengthens the picture of bikes being low-value goods.

Bikes in the Netherlands are treated as commodities instead of prized possessions. Neglected bikes show a lack of care and attachment, which ultimately leads to early disposal. Despite the repair infrastructure, we recycle hundreds of thousands of bikes annually. By focusing on the neglect of current bikes, we could reduce the number of new bikes being sold to satisfy market needs. The contextual research uncovered the most important problem, which is the unsustainable behaviour of users during the life of the bicycle. For these reasons, it seems logical to address sustainability in the bicycle industry through the user-bicycle relationship.

## 2. How can retention be supported by Design-for-DIY?

In the previous chapter, different pathways towards a more sustainable future with bicycles were discussed. Traditionally, the focus within a circular economy is on reuse, repair, refurbishing and recycling. But rather than finding a solution for the product after disposal or failure, we can focus on the retention of the product. Retention is fundamentally different from other circular economy strategies because it prevents products from losing their value in the first place.

This chapter introduces the value trade-off model as a way to look at retention behaviour in paragraph 2.1. It is then used to look at the retention of city bikes in particular, in paragraph 2.2. In paragraph 2.3, I present my model explaining the boundaries between the terms maintenance, repair and making, which are used interchangeably in the fields of product care and DIY. And finally, these terms are related to the values from the value trade-off model in paragraph 2.4.

### 2.1 The value trade-off model

To understand how DIY can support retention, we first need to examine why people choose to keep or replace their bicycles. Products are replaced for many different reasons. As a theoretical model to describe this behaviour Sheth et al. (1991) has suggested looking at products in terms of 5 values. Although originally used as a means to describe purchasing behaviour, it can also be used to describe the decision to replace. This model has been extended by Ackermann (2021) to describe replacement decisions by suggesting that customers not only evaluate the perceived value of the new product, but also look at the value of the product that they already own.

These values can be divided into five categories: functional, emotional, social, epistemic and conditional. The functional value is an indicator of how well the product works. For a bike, this could mean the resistance that increases over time because of a worn-out bearing or the brakes that don't work as well anymore. The emotional value describes the bond that you have with the product. When you had your first bike as a kid, it might be loaded with memories of that moment or a time past. Similarly, a bike used for travelling might be associated with the stories from that trip. A product can have a social value because it makes you feel part of a group. People who ride a fixie (fixed gear bike) associate themselves with a certain bicycle culture. The epistemic value is described as the feeling of 'newness' that a product has. This feeling diminishes slowly as new features lose their novelty and a product accumulates signs of wear. Lastly, there are conditional values that determine the purchasing or, in this case, replacement behaviour. An electric bike can have a higher conditional value for someone who is in poor health, for example.

These values play a critical role in the trade-off between keeping the current product or replacing it with a new one. Contrary to the values of the current product are the perceived values of the alternative. The user can make a picture in their head about what owning the new product feels like. If the difference in value between the two products outweighs the financial investment, the customer decides to replace. The value trade-off model is shown in Figure 15 on the next page.

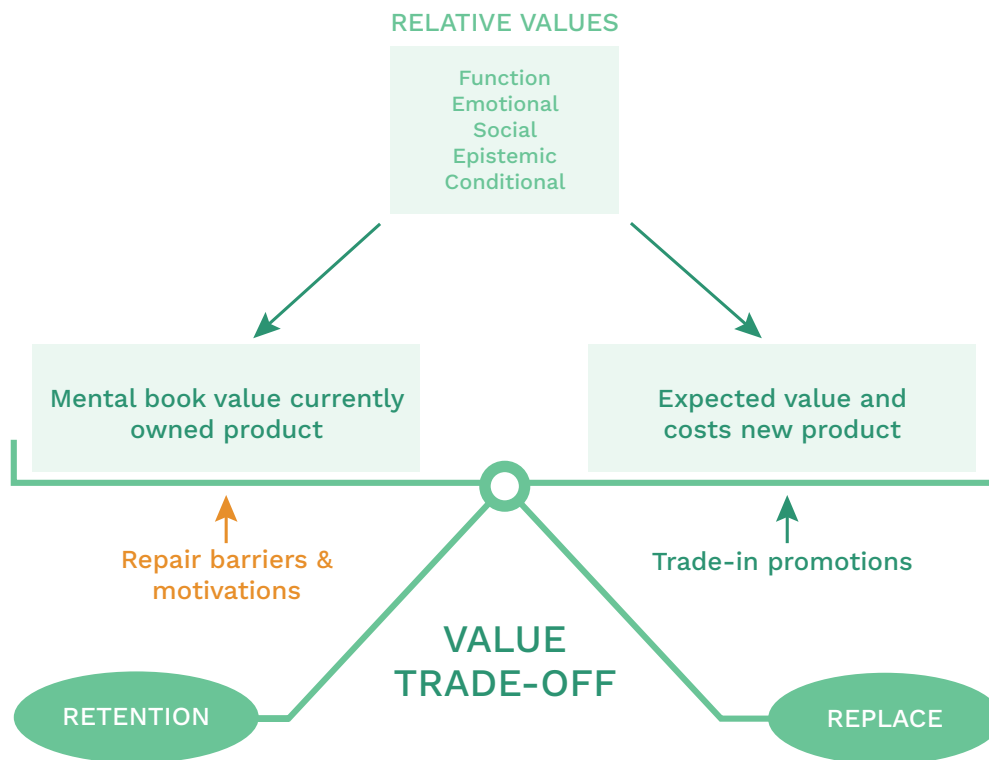


Figure 15: Value trade-off model based on (van den Berge et al., 2021)

It is very important to note that the value of the current product typically decreases over time. Customers tend to keep track of the value of the product in their heads, which is called the 'mental book value'. People can feel that the product has made their money worth when it has been in use for a long time. This differs from person to person, but it describes a declining trend of product value. Through continued use product become part of our daily routines and become habitual, giving feelings of satiation. This can lower the mental book value of a product, together with aesthetic wear. Feelings of satiation can cause people to replace their product before any aesthetic or performance losses. Emotional value and thus product attachment, turn out to be the only effective way to counteract feelings of satiation (Hou et al., 2020).

From the five values making up the mental book value, only 4 form the basis of the research. The conditional value will not be discussed because the strategies proposed by Ackermann and others towards product attachment (Ackermann et al., 2021; Haines-Gadd et al., 2018) don't address it directly. The other values are relevant and will be discussed individually.

## 2.2 The retention trade-off for city bicycles

Bikes are mainly valued for their functional value. When a repair is necessary, people assess the values of their current bike compared to a new or second-hand one to decide whether they want to replace it. Repair marks the moment when people make a rational decision between repair and replacement in terms of financial investment.

Because of this focus on functional value, it would be logical for people to maintain their product, but this is not the case. Firstly, we tend to take more care of products that are expensive (Ackermann et al., 2018). Bikes are very cheap and accessible, but their low price can cause people to postpone maintenance initially. At the time of repair, the low initial purchasing price, together with the low price of second-hand bikes, can lead to replacement. Because the second-hand market is very big in the Netherlands, it can be more beneficial to replace a bike than to maintain it from a financial perspective. This is an example of how the decision to replace is often rationalised for cheap commodity goods.

The lack of maintenance is caused by a focus on functional value and market influences. It also indicates low levels of product attachment. People tend to take care of the products that they feel attached to (Ackermann et al., 2018).

For many products, market trends influence people's decision to replace before the end of a product's life. Emotional and social values are usually important to prevent early replacement (Hou et al., 2020). This is less relevant for city bikes because changes have been gradual from the traditional omafiets to the modern-day city bike, and the old models are still being produced.

To increase the retention of city bikes, it is important to focus on attachment. Firstly, as a way to lead to maintenance during the life of a bicycle and secondly, as a way to influence the value trade-off towards retention when a repair is needed.

### 2.3 Defining DIY practices

Do-it-yourself activities offer a promising approach to building and maintaining the values that support retention, according to Ackermann (2021). The problem is that within the literature, there seems to be an overlap between the fields of product care and DIY in terms of their definition. To solve this problem, I've come up with my own model to divide these activities into: maintenance, repair and making.

According to Ackermann et al. (2018) Product care are all the activities that extend the life of a product. This includes both maintenance and repair. Similarly, there seems to be a double meaning in the field of DIY. DIY is commonly referred to as "the method of building, modifying, or repairing things without the direct aid of experts or professionals" (Bonvoisin et al., 2017). Here, the terms repair and making (building or modifying) are used interchangeably, while they have profoundly different meanings in the context of my research.

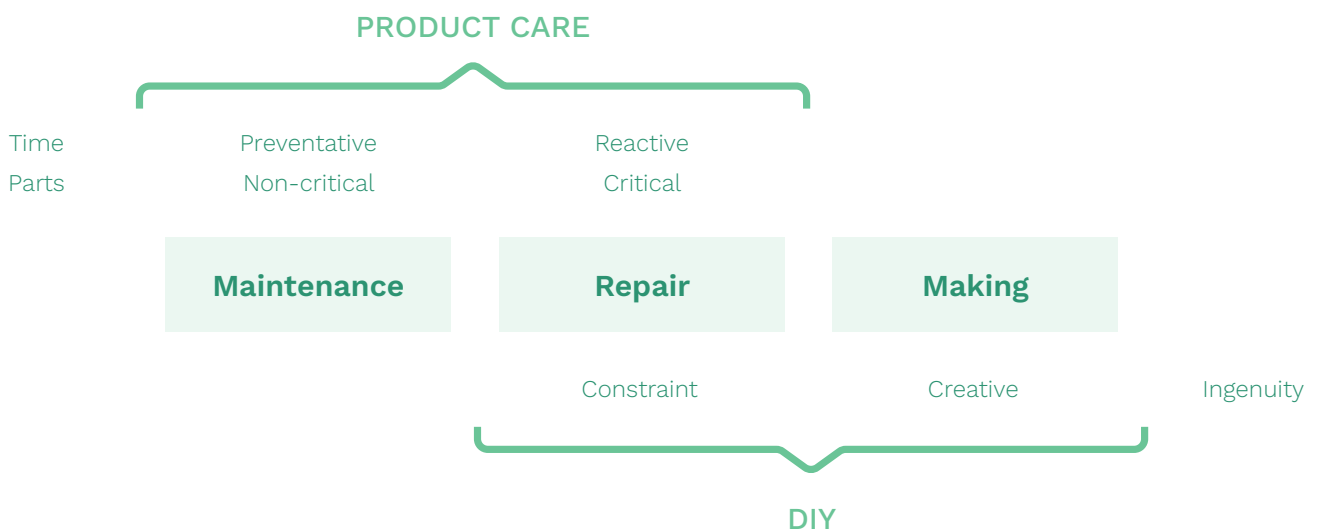


Figure 16: A model for categorizing DIY practices

#### Three main take-aways:

- Maintenance, repair and making are described as three distinctly different DIY practices.
- Repair is a reactive practice that happens when a critical part of the system fails. It becomes a critical moment in the decision to keep or discard a bike.
- Making offers more opportunities for creativity than maintenance and repair.

### 2.3.1 Maintenance

Examples of common maintenance practices are tensioning and lubricating the chain and pumping up the tyres. Chain oil protects the chain, and the right tyre pressure can prevent a puncture. Protecting your bike from the rain or cleaning it when it gets dirty are also considered maintenance. This allows your bike to stay in optimal condition because weather and grime not only have an effect on aesthetics, it can also corrode surfaces and cause wear in mechanical parts.

In chapter 1, a group of parts was identified that didn't cause users to take action. These included a broken fender, lights, a chain guard, a broken front or rear rack and sometimes even a brake. Of course, these parts didn't fulfil their individual purpose anymore, but looking at the bike as a whole the bike wasn't broken.

Even within this category of parts, there is a difference in how their failure affects the perception of the bike. A missing chain guard and a broken fender make the bike dirtier. An exposed chain collects more dirt and grime that can wear it down. At the same time, rain can speed up the corrosion process and cause it to rust. With a chain guard, the chain wouldn't wear as quickly, and the user wouldn't be made aware of any wear that is happening. Without fenders, the bike collects dirt more easily, and it can also become an inconvenience for the user when the water from the road is splashed on their clothes. Together, this has an effect on the perception of decay.

A broken light and a broken luggage rack do take away secondary functionalities of the bike. Without lights, you cannot cycle at night without running the risk of getting a fine, and without a storage rack, we have to find other solutions if we want to carry larger or heavier things on our bikes. Although these functionalities are not strictly necessary, they do change the perception of functional value and force people to change their behaviour.

A broken brake is a grey area when it comes to maintenance. Brakes are undeniably a critical feature of any bike, but observations on city bikes showed that one broken brake was not enough reason to take action. Adjusting the tension of the brakes and changing the brake pads before they wear out would be part of the traditional definition of maintenance. According to the current definition, however, changing a broken brake cable to one of the brakes would also be considered maintenance.

Many of the non-critical parts that are named above are repaired by users with duct tape or zip ties. This is possible because they are often not mechanical parts with technical requirements. And from a DIY perspective, these methods should be encouraged, but they also contribute to the aesthetic perception of decay.

Postponing maintenance has a significant influence on how the bike wears down and how it is perceived over time. Lack of maintenance reduces the value of the bike both in terms of monetary value and the perception of decay. Most preventative measures are not performed because it is unclear how much effect they will have on the extension of the life of the bike. Broken parts that are not critical to the main function of the bike can cause frustration and also reduce the functional value of the product. Ultimately, maintenance is essential to maintain functional value and to reduce perception of decay.

### 2.3.2 Repair

According to my personal model, repairs are all the activities performed to fix a critical failure. Examples of these critical failures would be a puncture or a broken chain. Without these parts, you really cannot use the bicycle. Repair is, therefore, a reactive practice that only happens when the functional value of the bike has completely diminished.

From a retention perspective, repair represents a critical decision point. People are forced to choose between repairing and discarding their bike, and this choice is heavily influenced by the current mental book value (as described in the value trade-off model). In addition, it is suggested that the cost and the effort of the repair are weighed as a factor in the value trade-off. Therefore, repair should be prevented, because repair creates an opportunity for a replacement decision, where low perceived value and attachment can lead to disposal.

### 2.3.3 Making (customization)

Making in this context means customising your product by changing its aesthetics or its functionality. By changing products aesthetically, we can make them more unique and our own. The product can start to reflect our personality. Customisation can also change the functionality so that the product is able to satisfy our needs better. But in essence, the making process changes a product so that it becomes less replaceable.

I give an example of a customised bike in the preface of this report. My own bike is a collection of many different parts that I put together. I've also changed the colour of the handlebar tape to match the aesthetics of the rest of the bicycle. In this way, I have added my own taste to the product, making it unique. I can definitely say that it holds more value to me because of these changes.

Other ways of making and customising might include painting the frame, adding stickers or accessories and changing the functionality with additional parts. These changes can help to further personalise the bike.



Figure 17: Custom paintjob on bicycle (Merijn, 2019)

## 2.4 How DIY practices influence retention values

Having defined the three DIY practices, we can now examine how each influences the specific values in the retention trade-off model. Understanding these relationships reveals which DIY activities are most strategic for achieving the goal of retention

### 2.4.1 Functional Value

Functional decay is a part of any mechanical system's life. Mechanical and technical products especially need maintenance in order to keep their functionality.

**Maintenance** is the primary way to preserve functional value during the life of the product. By lubricating a chain, adjusting the brakes and keeping the right tyre pressure, users can extend the life of their product and get a more pleasurable experience from the product in the moment. As a preventative measure, it slows down deterioration by preventing wear and can lower the risk of a critical failure. Maintenance keeps the functional value high throughout the life of the product.

**Repair** can restore functional value after a critical failure, following the definition put forward by this report. Even normal use has a chance to lead to a critical failure so it is part of retaining a product, but when a repair is necessary, the functional value is considered to be zero.

For commodity goods like city bikes, which are mainly valued for their functional value, critical failures must be resolved as fast as possible. Making the repair process easy and convenient is therefore very important.

**Making** typically doesn't work toward retaining the functional value of a product. It is possible to add functional value with customisation by making the product more specialised for one specific use case. But generally customisation has an influence on the aesthetics of a product that have influence on the social and emotional value rather than the functional value of a product.

### 2.4.2 Emotional Value

Research has underlined the importance of emotional value for sustainable consumer behaviour (Chapman, 2009). Before a product fails, emotional value can make people less susceptible to market trends because they feel an emotional connection with the product. This emotional bond can be called product attachment. If people feel attached to their product, they are less likely to discard it (Mugge, 2007).

Aesthetics are also considered part of the emotional value of a product. Here, personal taste and market trends play an important role in the pleasure that a product can offer to the user. Over time, as products wear, their aesthetic value diminishes, also reducing the emotional value.

**Making** plays a role in emotional value in multiple ways. Customisation has an influence on how attached people are to their product. We feel more connected with the things that we make, because we influence how they look and how they work for us. It allows us to have a certain level of creativity that we don't experience in repair and maintenance.

Customisation also makes our products more unique and irreplaceable. When you have invested your own time and effort into making, this effort is lost when we decide to replace a product. This irreplaceability adds value to the product through the attachment.

**Maintenance** has a more complex relationship with emotional value. Interestingly in the English language, when we talk about repair and maintenance as taking '*care of something*'. Attachment could also be described as '*to care for something*'. Intuitively, we associate attachment with maintenance. It turns out that people are more likely to take care of products they value and are attached to (Niinimäki & Koskinen, 2011).

This can explain why we take care of vintage cars for example. Attachment is usually the main reason for this care. Sometimes the product can hold memories from a time past or they are inherited and hold a deeper meaning (Grayson & Shulman, 2000).

However, maintenance can also lead to attachment and thus emotional value (Ackermann et al., 2018). "While cherished products are more likely to be well taken care of, executing repair activities may also enhance the emotional value that resides in this product if these repair activities evoke positive emotions." This is why Swapfiets makes it difficult for people to build a relationship with their bikes, because the process of taking care has been outsourced. We are not allowing people to create an attachment with their product. To conclude, maintenance can only lead to attachment when the activity is associated with positive emotions (this will be further explained in Chapter 3).

**Repair** as a response to failure can have different effects on emotional value based on the context. For people who purely value their bike for its functionality and don't feel attachment, the repair can cause frustration and further reduce emotional value. Where people who already feel attached to their product can potentially strengthen the emotional bond by 'keeping the product alive'.

### 2.4.3 Social Value

Social value refers to how a product gives you the feeling of being part of a group. In the case of DIY activities, group affiliation can come from either the product itself or the activity and what it says about your personal values and beliefs.

**Maintenance and repair** say more about the value of the activity. People who care about sustainability will be proud to show how long they have been using a product ("I've been using my phone for 5 years already"). Short product lifespan is associated with consumerism, and in groups where people share this same belief, product care is praised. The problem is that this is specific to certain groups, and that definitely not all people share this conviction. In addition, repair and maintenance are not always directly visible. Some people might take pride in having a clean car. They maintain the aesthetic of their car because it can say something about them as a person. For bikes, this is not common because they are culturally not as perceived as a symbol of status and not considered a prized possession. The social value pinpoints the importance of culture in repair and maintenance.

**Making** creates a more visible social value through the product itself. When people customise their bikes by painting them or adding decorations, they sometimes do this to associate themselves with a particular social group. Swapfiets has made effective use of this by making the front tyres of all their bikes blue. Besides being a recognisable feature for their brand, it also creates the feeling of being part of a social group. An important distinction between repair and making is the lack of visibility of repair in the social context.

### 2.4.4 Epistemic Value

"Epistemic value is described as the capacity to arouse curiosity, provide novelty and/or satisfy the desire for knowledge." (Sheth et al., 1991). For a new product, the epistemic value is high because they sometimes provide new features which are not part of our routines yet. But as we develop habits with the products around them, they lose their 'newness'. It is possible, however, to create epistemic value during the use of a product. By adding new features to a bike in the form of a GPS system or by converting the bike into an electric bike, the epistemic value can be renewed. But typically, products don't give a feeling of novelty later on in the product's life.

**Making** offers the strongest opportunity to give a feeling of novelty and drive curiosity after purchase. DIY can give a bike new functionalities by adding features or making it more useful for someone's specific use case, and at the same time, it can arouse curiosity and satisfy the desire to acquire knowledge because of the techniques and skills required in the making process.

**Maintenance and repair** have a minimal effect on epistemic value. In the best case, they bring the product back to its original state. Maintenance and even repair don't change the aesthetics or functionality of the product compared to the state of the product before it was bought, and thus their effect on epistemic value is negligible.

## 2.5 Conclusion

This chapter described how the three different DIY strategies: maintenance, repair and making, can contribute to retention through the value trade-off. It also emphasised the central position of attachment, or the lack thereof, in the decision to replace products, especially for commodities like city bikes.

**Maintenance** is essential for preserving functional value and preventing the perception of decay. It can simultaneously foster attachment when the activity itself is considered pleasurable. However, maintenance faces adoption barriers: people don't maintain city bikes because the benefits seem unclear and because low attachment reduces motivation for care. This creates a problematic cycle where lack of attachment leads to neglected maintenance, which accelerates decay, which further reduces attachment.

**Repair** represents a critical point in the life of a bicycle. When repair is needed, the bike has completely lost its functional value to the user. Therefore, it prompts a retention decision based on the value trade-off. For city bikes with low attachment and a low cost of replacement, this trade-off often leads to disposal. Repair is very necessary, but not enough as a retention strategy.

Because bikes are very functional objects, they lose their functional value when a critical part fails. Therefore repair should be made as effortless as possible. Unlike maintenance, which has the opportunity to foster attachment when it is found to be a pleasurable experience.

**Making** offers the most powerful mechanism for building attachment through emotional value. Customisation creates uniqueness, enables self-expression, and involves owners in creative processes that foster a better product relationship. Making can also add epistemic value through novelty and learning, and create visible social value through group affiliation. However, making typically doesn't preserve the baseline functional value that maintenance provides. This is problematic for products for which the functional value is the most important.

For city bicycles specifically, we should focus our attention on attachment as a foundation for retention. Attachment serves two purposes: encouraging ongoing maintenance behaviour that prevents decay, and influencing the repair-or-replace decision toward retention when failures inevitably occur. Given that city bikes are primarily valued functionally and exist in a market with cheap replacements, emotional value becomes the critical differentiator that can prevent people from buying a replacement.

*Design-for-DIY* should therefore prioritise attachment through two different avenues: maintenance and making. This led to two research questions to find more potential design opportunities: "What are the barriers and motivators that influence the maintenance process?" as reducing barriers and designing for motivation can foster pleasure in the process. And "How does engaging in making and maintenance change the human-bicycle relationship?", to further understand how making leads to product attachment. These questions are explored in Chapters 3 and 4.

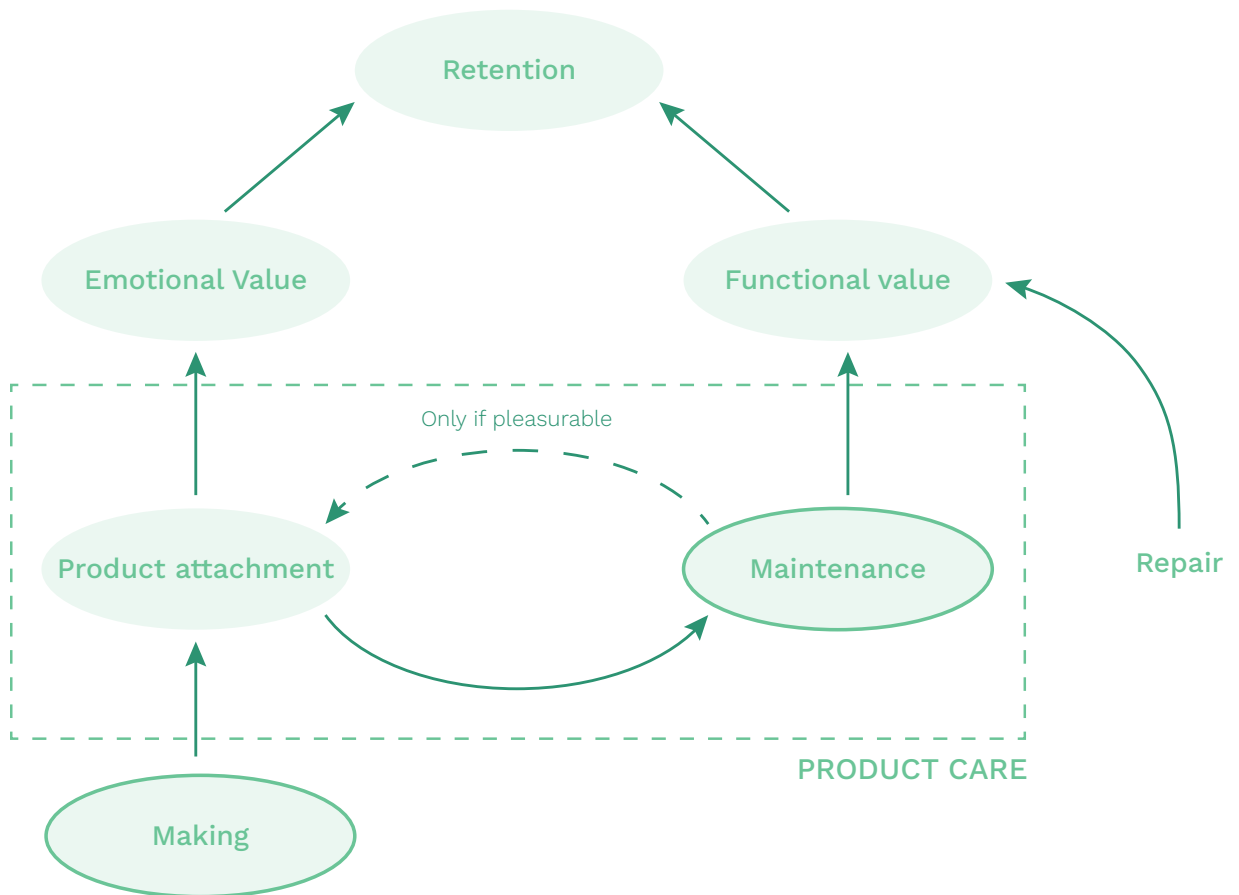


Figure 18: The relationship between different retention strategies

### Three main take-aways:

- Product attachment is central towards retention of city bikes.
- Making and maintenance offer two potential strategies towards product attachment.
- Maintenance can only lead to product attachment when the activity is pleasurable.

## 3 What are the barriers and motivators that influence the maintenance process?

One of the interesting insights from Chapter 2 was the fact that maintenance and repair can only lead to product attachment when the activity is pleasurable (Desmet, 2012). These pleasurable activities are, for example, oiling wood or treating leather. But how does this relate to bicycle maintenance? Is it possible to feel pleasure in maintaining bicycles? Because of this insight, this Chapter focusses on the barriers and motivators which are part of the maintenance process. The reason is that by removing barriers and increasing motivation, there would be an opportunity to make maintenance a more pleasurable experience.

### 3.1 Comparing different models for barriers and motivators

Many different models are presented to explain the barriers and motivators towards repair. These follow the behavioural model by Fogg (2009). He proposes that in order to change behaviour, we need three things: ability, motivation and a trigger. In order to perform the behaviour, people need to be able to do it. This can be achieved by alleviating barriers, making the process easier. Secondly, they need the motivation to do so. These motivations can be both internal and external. And lastly, there needs to be a trigger or prompt that encourages people to do the action. I decided to leave out triggers as they don't directly lead to pleasure and because they can be formulated as motivation according to Dr Ackermann (personal correspondence, December 12, 2025, see Appendix 2).

Usually, these models are focused on repair. Repair is an important strategy towards a circular economy, and has thus gotten a lot of attention. But as put forward by this report, repair happens at a moment when all functional value is lost. However, because maintenance includes repairing non-critical parts (as defined by this report), research about repair is still relevant for answering this chapter's research question.

Two models were compared to get a comprehensive look at the field of repair and maintenance. The Repair Motivations and Barriers model (MBR) was chosen for its focus on 'aesthetic repairs' performed by users themselves (Terzioğlu, 2021). These didn't include technical repairs like repairing mechanisms and electronic circuits, and are thus more in line with the definition of maintenance put forward by this report. Secondly, the model by Roskladka et al. (2023) was chosen as it is a result of a comprehensive literature study into barriers and motivators, specifically focused on more complex household appliances. It formulates all the findings as barriers from the easiest to overcome, technical barriers, to the more complex, and the willingness to repair.

These two models were both analysed in order to find differences and overlap. Insights from three bicycle repair sessions and interviews, from my own research, were added to make this model more specific to bicycles. Lastly, these factors were evaluated to find the ones that affected the pleasure and enjoyment of the process. Leading to opportunities to create product attachment through the act of maintenance.

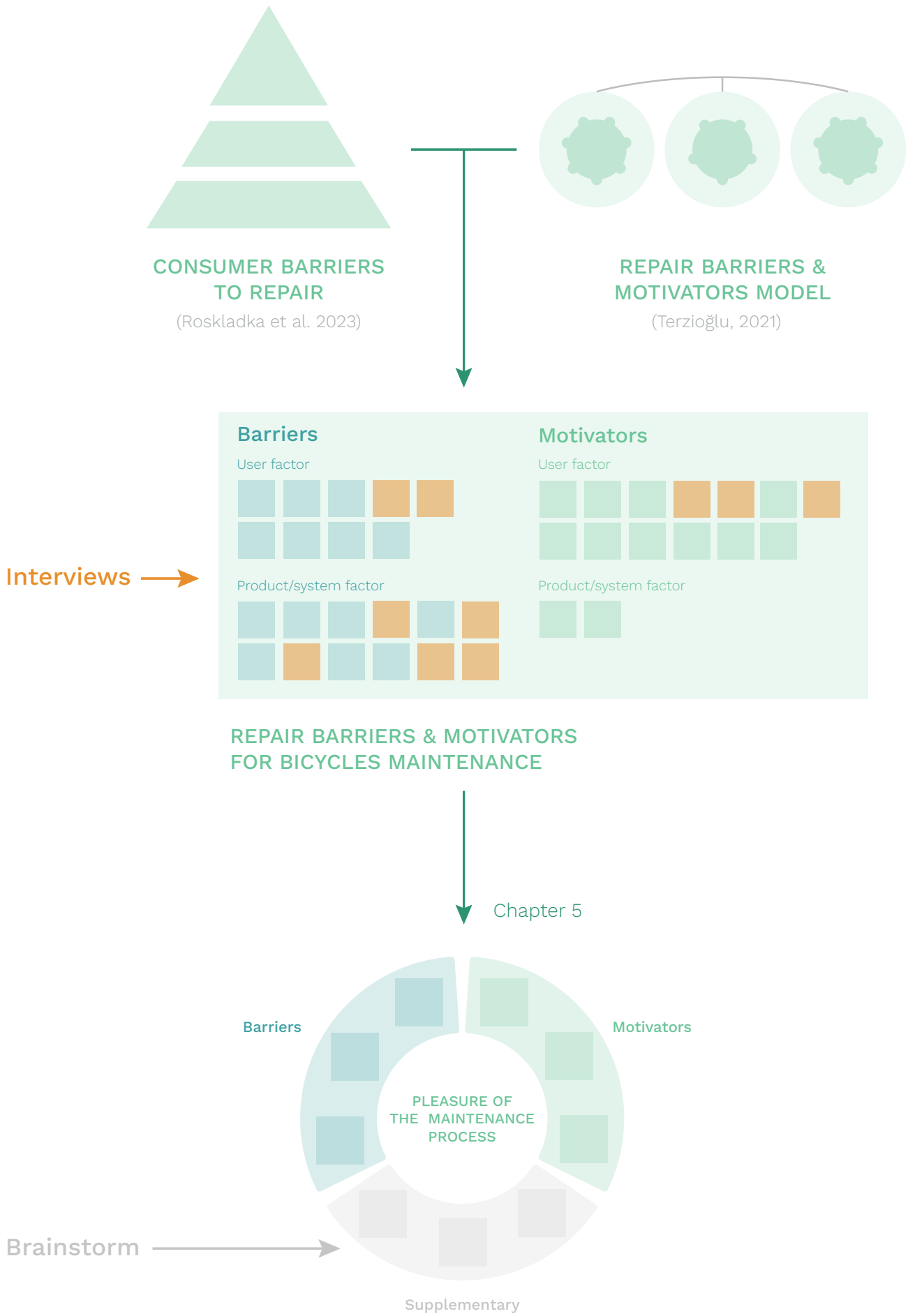


Figure 19: Process overview Chapter 3

## 3.2 Repair interviews

To get an understanding of the maintenance and repair process, I invited three people to the faculty workshop to fix their own bikes. I chose to interview people who had little to no experience with bike repair or mechanical repairs in general, but who were curious to learn more. I guided them during the process, but with 'my hands on my back' meaning that I was not allowed to interfere. Afterwards, I held a 30-minute interview to ask questions about their experience and their relationship with the bicycle. The following insights were gained during these repair interviews.

### Barriers

- **Fear of failed repair:** Because bicycle maintenance and repair are such a big part of Dutch cycling culture, everybody has their own bad experience or has heard of failed bike repairs. This can lead to a lack of self-efficacy in repairing bicycles.
- **Failing to diagnose the problem:** A person who understands how the product works will be able to understand the problem from the feedback that the bike gives during a ride. A lack of understanding can lead to a false diagnosis, for example, connecting unrelated events. One participant who had a very rusty chain said, *"Maybe a new chain will fix my gears."* Another participant said, that the *"The gears are just a bit weird."*
- **Grime and mud:** Most of the bikes accumulate a lot of dirt and grime on the chain, the wheels and fenders, which doesn't make it nicer to work with. One person asked for gloves to work on the bike before starting to work on it.
- **Confusing part names:** When looking for parts, people are faced with many different names and standards. When looking online, this means that you have to know what the part is called and where to find it. One participant had the following experience finding a new chain: *"The guy at the store asked me what kind of chain I needed, 7 or 9 speed. I said eight, but he didn't believe me. Then he looked at my bike and said it was a single speed. If I had bought it online, I would have bought a 8 speed chain for sure."*
- **Availability of repair services:** Unique to the bicycle market is the availability of repair shops. Of course, these shops help increase the number of bikes being repaired, but they can be seen as a barrier when it comes to self-repair. People who are not confident in their ability to repair are less likely to learn how to maintain their bike because there is an easier alternative.
- **Chance of theft:** Knowing that your bike is more likely to get stolen if it is fully functional discourages users from performing maintenance.
- **Indispensability:** Because we are so dependent on our bicycle for daily commutes we don't want to run the risk of using alternative transport for going to school or work. This leads many people to postpone maintenance.

### Motivators

- **Previous successful repair experience:** Participants told me that a previous successful experience could motivate them to do it again. After doing it once with help, they said that they would dare to do the same repair by themselves in the future.
- **Repairing together:** The participants also said that repairing together made it a lot more enjoyable. Whenever they felt like they were getting stuck, there was always someone to fall back on.
- **Perceived ease of repair:** This point seems evident, but I felt like this point was not covered by the other papers. When we think the repair is easy or when we think that it falls within our skill set, we are more likely to do the repair than if it seems very complicated.

My personal observation is that most of the barriers can be attributed to a lack of experience. When people have not tried to repair things in their lives before, they can be reluctant to try it. And then when they start, there is an expectation that it will be straightforward. But when you run into unforeseen problems or setbacks, the process becomes frustrating, and people can lose their sense of confidence. At the same time, the motivators that are mentioned in this section all contribute to confidence in some way. We can conclude that confidence is an important factor in the maintenance process.

### Teaching children how to repair their bike: Bouwkeet Rotterdam

Bouwkeet is a non-profit that focuses on teaching children from Rotterdam to make things. Their longest-running program is called 'Earn Your Own Bike'. Children get to choose a discarded bike that has been picked up by the municipality. In 12 weeks, they will completely disassemble, paint and decorate the bike with custom-made stickers.

The course begins with fundamental knowledge that students will need throughout, such as tool names and their respective uses. They have found that after this early introduction, the program should follow with a small project to foster an early sense of achievement. The educators found that this early sense of success can keep children excited throughout the rest of the course. However, the bike repair program is the only program where they haven't been able to give the children this sense of accomplishment in the first lesson.

The repair projects give less freedom for the teachers to give this experience of success. And this feeling of success is especially important for children who are uncertain about their own abilities. Bouwkeet has experimented with having children make a bell in the first lesson, but they failed at making this first step easy enough, the creative director told me. Maybe repair-based projects offer fewer possibilities for creating a successful experience.



Figure 20: Children restoring a bike at the Bouwkeet Rotterdam (Jorritsma, 2016)

Beyond improving technical skill and knowledge, Bouwkeet focuses on developing soft skills through the making process, such as collaboration, creativity and problem solving. In the end, they hope to empower the children and to broaden their horizons. In a survey held among the children, a measurable impact was found when it comes to empowerment (White & van der Linden, 2020). The impact that programs have on creativity and the ability to repair was more difficult to quantify, but group dynamics turn out to have a significant impact on the development of soft skills.

The programs at Bouwkeet have the most impact on the children's feelings of accomplishment. However, it is not easy to give the children this feeling on the first day when doing repair projects compared to the more creative making projects. Besides having an initial successful experience, working together with peers seems to be the most important to give a feeling of accomplishment.

### 3.3 Comparing different models for barriers and motivators

This model combines the findings from two repair papers and the interviews that I've conducted to present a new model for the maintenance of bicycles performed by the user themselves. Both the barriers and motivators were categorised into user and product/system factors. The RBM model introduces perceived pleasure and perceived interest as two motivators that have not been mentioned in previous repair research (Terzioğlu, 2021). Especially perceived pleasure is interesting. It means that pleasure is not only necessary for maintenance to lead to product attachment, but a seemingly pleasurable process can also motivate people.

**Barrier** something that prevents you from taking action

Personal factor



Product/system factor



**Motivator** something that encourages you to take action

Personal factor



Product/system factor



Figure 21: Maintenance Barriers and Motivators for maintenance

### 3.4 Pleasure in bicycle maintenance

Following the research by Dr Desmet (2012); we can say that attachment through maintenance can only be achieved if the process is pleasurable. But what does pleasure mean? Pleasure is described as 'a feeling of happiness, satisfaction and enjoyment.' We could say that removing any barriers can make the process more enjoyable, and some motivations target the enjoyment that can be gained from the maintenance process, therefore contributing to pleasure. This Paragraph concludes with a model for pleasure in the process based on research by Dr Csikszentmihalyi and Robert Pirsig.

#### 3.4.1 Pleasure in bicycle maintenance

Pleasure of the process, according to Csikszentmihalyi (1990), is a feeling of contentment within an activity. Whereas, enjoyment is a result of going beyond someone's prior expectation. Enjoyment is therefore closely related to novelty and has an element of surprise. This is hard to obtain with repair and maintenance, I believe. Because people are not creating something new, there is a smaller chance that they will be surprised by their own creativity. With maintenance, the product can only be brought back to its original condition, which doesn't lead to surprises.

Csikszentmihalyi further describes eight elements which are part of enjoyment. The task should have a clear goal, it should have a reasonable chance of success, it should give immediate feedback to the user, give a sense of control over their actions, give deep effortless involvement, make people lose sense of time and be less concerned about themselves. These elements can be implemented by designers to make a process more enjoyable.

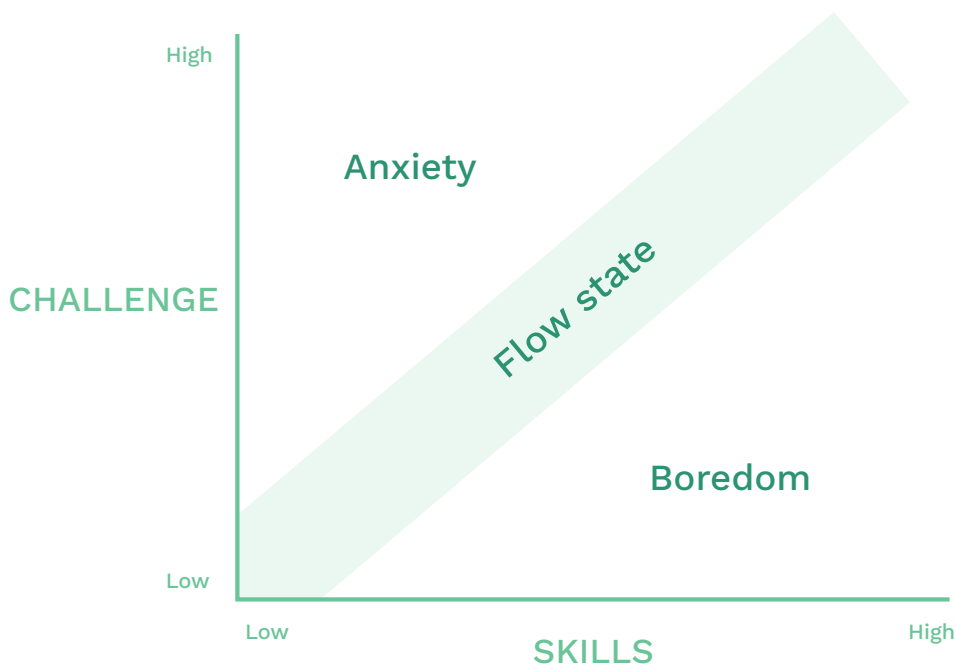


Figure 22: Flow, a balance between challenge and skill, own image based on Csikszentmihalyi (1990)

The flow state can be achieved when there is a balance between challenge and skill. This balance is often not achieved in the bicycle maintenance process because it is difficult to predict the challenge at the start and because new skills often need to be acquired based on the problem at hand.

### 3.4.2 Getting stuck

I think that the maintenance process is really difficult to make pleasurable. It is not the process itself, but more the feeling of accomplishment as you finish the task that leads to satisfaction and pride afterwards. The problem is that getting stuck is an inevitable part of the process. Robert Pirsig describes this in his book, *Zen and the Art of Motorcycle Maintenance* (1974), as a gumption trap, which captures the essence of this experience very clearly.

Gumption is described as the drive that people experience to start and finish a project. For repair, it means the focus and motivation that you need to get to the finish line. High levels of gumption are the attention that drives a project. Pirsig coined the term 'gumption trap' in his book to explain the internal and external setbacks that can be experienced while repairing something. An external setback can be a rusted bolt that is difficult to loosen, or breaking a part in the middle of an assembly and having to wait for a replacement. Internal setbacks are related to your self-confidence while repairing.

I've known this term since I was 14, when I started to take things apart. Inevitably, I would sometimes get stuck in the process. To be able to talk about this, my dad introduced me to the term. I think I realise now that gumption traps can never be completely avoided. But by knowing that gumption traps are part of the process, it was easier to deal with the frustration. I also think that these setbacks can make repair or maintenance that much more rewarding, because it leads to enjoyment when you do manage to finish the repair. This doesn't take away, however, the fact that Gumption traps are an inevitable part of the repair and maintenance process and can lead to frustration for inexperienced users.

## 3.5 Conclusion

Getting stuck is an inevitable part of repair and maintenance that can lead to frustration. This is an effect of mechanical wear, rusted bolts, and missing parts, among other things. It makes repair an unpredictable process, because it is uncertain what tools, skills and materials you will need in order to finish. Pirsig describes this as gumption traps in his book '*Zen and the Art of Motorcycle Maintenance*.' At the same time, overcoming these setbacks is what makes repair so rewarding.

The feeling of pride is usually achieved at the end of a repair project, but Bouwkeet in Rotterdam found that feeling empowered is crucial throughout the whole process, specifically at the start. Bouwkeet offers this in their making projects through an initial experience of success, by creating something small at the start. However, with a repair-based project, they haven't found a way to create this initial feeling of success.

Pleasure in the repair and maintenance process is difficult to achieve. The process is unpredictable and rewards the user only at the end. If designers want to make the process more pleasurable, they should focus on the psychological side, meaning designing for confidence, feelings of accomplishment and working collaboratively, besides taking away more practical barriers.

## 4 How does engaging in making and maintenance change

In chapter 2, products were observed through the lens of product values. It was found that emotional value, or product attachment, is most important in people's decision to replace their bike or not. But product attachment is part of a broader human-product, or in this case, human-bicycle, relationship. This chapter explores how this relationship is influenced through the maintenance and making process.

### 4.1 Investing time and effort - The IKEA effect

The IKEA-effect, described as the increased valuation that people have with self-assembled products, is a well-known result of DIY. When people put in effort in the form of time and energy, the relationship and attachment strengthen (Norton et al., 2012; Mugge et al., 2009).

Norton et al. (2012), in their paper about the IKEA effect, say that 'labour leads to love' but only if the activity is successful. This is similar to the finding from chapter 2, saying that maintenance only leads to attachment when it is pleasurable. IKEA is able to control how successful the experience is by tight quality control, well-thought-out manuals and customer support. This is more difficult to achieve in the maintenance and repair process as it can be very unpredictable (see Chapter 3).

### 4.2 Product experience

Another part of the user product relationship is how users experience their product. Desmet & Hekker (2007) divided product experience into three categories: Aesthetic experience, experience of meaning and emotional experience.

People are found to appreciate the aesthetics of their own creations more than those of products designed by someone else (Franke & Piller, 2004).

Secondly, by engaging ourselves in the design and making of an object, we automatically give it symbolic meaning. The product carries the thoughts and personality of the person who made it (Govers & Mugge, 2004). And the creative freedom in the making process gives us the opportunity to add parts of ourselves to the product.

Lastly, the emotional experience is directly related to attachment. Attachment is the emotional bond that we have with our products. Mugge (2009) says that a strong emotional bond is formed through an effortful process. This also explains why it is easier to become attached to self-made objects compared to industrially produced ones (Belk, 1988; Mugge, 2007). When we compare customisation and maintenance after purchase, they differ strongly in how much effort it takes. Maintenance generally takes less effort than making, and therefore making leads to stronger feelings of attachment.

### 4.3 The extension of 'Self'

By knowing objects, mastering them (appropriation) or by creating an object, they can become an extension of people's self (Belk, 1988). This is the strongest form of human-product relationship.

#### Knowing

Knowing is the first step in making products part of one's self. As we learn about them and as they start to become part of our daily routines, we start to understand them better. We understand what that warning light in our car means, and we know how to set the time on our watch.

When we repair and maintain something, we learn more about the product. We turn the product around to look at the bottom, we remove a cover to see what is underneath, and we might learn where a weird noise was coming from. But when you make something, you automatically know it. Without knowing it, you wouldn't be able to put it together. Making a product thus forces people to have a better understanding of the products they use.

## Appropriation

The next step is appropriation or mastery of the product. Over time, some products or tools become an extension of ourselves because we don't think about them anymore. For a smith, the hammer becomes an extension of their hands. Through many hours of deliberate use, they have learned how it sounds, how it feels and how it responds. For bikes, this can also be true.

A bike can become an extension of oneself when we learn how it feels. When we understand that the chain needs oiling by listening to the sounds. When we can feel that the tyres are losing pressure, just by how much effort we need to put in going forward. This form of knowing is called appropriation.

## Making

The last one and probably the most direct way a product can become an extension of self, is through making. As we make and customize we invest parts of ourselves into the object, whether deliberately or not. Our previous experience, skills, thoughts and preferences are captured in the object. Belk (1988) describes it beautifully in the following quote: 'The ideas that we make things a part of self by creating or altering them appear to be a universal human belief'. According to Belk, making leads to the strongest form of human product relationship.

## 4.4 History of the product

The history of a product consists of its creation and its use and ends when it is discarded and incinerated or recycled. This is referred to as the biography of an object (Kopytoff, 1986). When we make and modify things, we are part of the history of the object. The maker is aware of all the small 'mistakes' they have made during the process. This is contrary to mass production, which is trying to achieve the highest form of repeatability at the cost of losing uniqueness. When we make things ourselves, not one piece will be the same. But this is also the beauty of it. The maker is the only one who is aware of the small 'mistakes' they have made, which creates a unique relationship between the creator and the object itself.

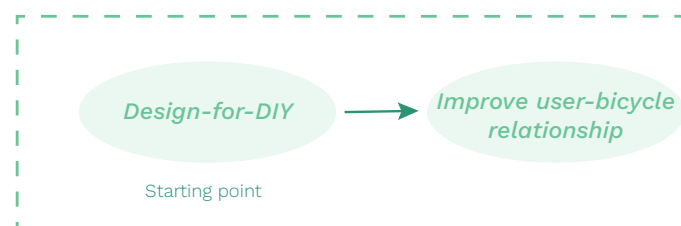
## 4.5 Conclusion

The user-product relationship is influenced by more than the emotional bond alone. The relationship becomes stronger because we invest our time, energy and a piece of ourselves into the object which can change the product experience and the history of the object. If we want to strengthen the relationship with the products we own, making and modifying are the most effective DIY strategies.

From this chapter, it can be concluded that making is much more effective in creating a human-bicycle relationship than maintenance. On a surface level, the relationship is influenced by the IKEA effect. By spending time and effort (labour) we get a more loving relationship with the product. Self-made objects are automatically loaded with meaning, and their aesthetic qualities are valued over those of mass produced once.

The strongest human product relationship is through the extension of self. This can happen in three distinct ways, but the most direct way is through the process of making and modifying. Because this process is more creative, we can adapt the product to our personal preferences and make something that is unique to us. Additionally, the maker is more aware of the history of the product, where the materials came from and what small 'mistakes' they made that make their product unique. Together, these aspects strengthen the user-product relationship.

### PROJECT GOALS



# 5 What design opportunities emerge to support DIY engagement and product retention for city bikes?

The initial goal of this project was to make the use of city bikes more sustainable, starting from a DIY perspective. The analysis phase has helped to understand the steps that sit between the goal and my starting point. These steps offer different points for intervention. This Chapter summarizes the findings from the analysis phase so far and introduces two opportunities, which will be further explored.

## 5.1 Correlation between project goals

In Chapter 1, I learned that the problem of sustainability is in the use phase of the product. Bikes are discarded way before most parts fail, so the goal should be for users to retain their products. Chapter 2 showed that most bikes are disposed of because of a lack of maintenance. Most maintenance activities are not needed for a bike to function, and people tend to postpone these activities as long as possible. But when a repair is needed (a critical part fails), users need to take action. At this point, the bike has lost most of its value and risks being discarded, so to prevent disposal, bikes should be maintained throughout their entire life.

Chapter 3, looked at the barriers and motivators towards the maintenance of bicycles. Maintenance was found to be inevitably frustrating, but there is an opportunity to focus on the psychological side of maintenance to increase the pleasure of the process. This opportunity will be explored in section 5.2.

Additionally, Chapter 4 compared making and maintenance as a tool to create product attachment. Making was found to be more effective in this regard than maintenance, but because bikes are seen as commodities with a relatively low value, it would be unrealistic to expect users to invest time in customising their bikes. By combining the benefits of making with the necessity of the maintenance process, a new opportunity emerges. This opportunity was called creative maintenance and is explored in section 5.3.

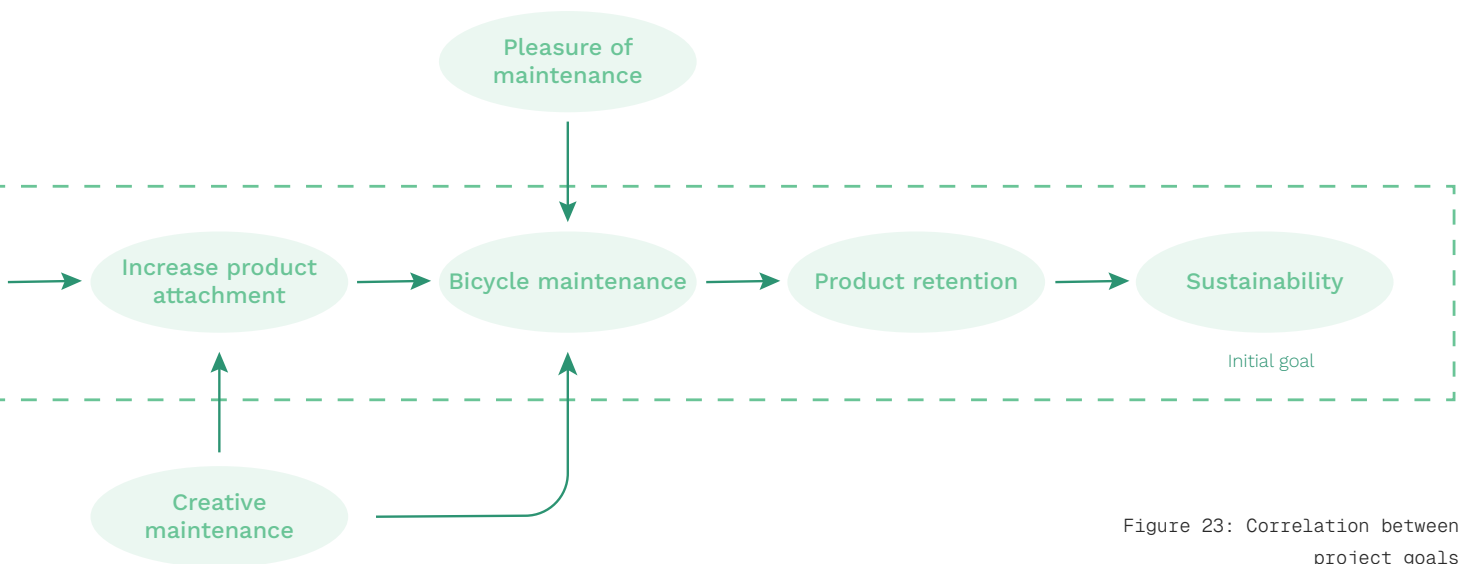


Figure 23: Correlation between project goals

## 5.2 Pleasure of the maintenance process

Chapter 3 introduced an extensive model with barriers and motivators for bicycle maintenance performed by users themselves. These factors can be divided into three stages of maintenance. These are the considerations that are made before attempting to maintain a product, during the process itself, and the resulting feelings or emotions.

To choose which factors are important during the process, I discussed them with fellow ID students. This resulted in 6 factors, shown in blue (barriers) and green (motivators). To see if there were any gaps in this model, a brainstorming session was held. This resulted in 3 additional factors, shown in grey, which complement the previous research. Together, these form a model to design for pleasure in the maintenance process.

A closer look at this model reveals the importance of designing for psychological barriers and motivators like confidence, feelings of achievement, and collaboration. These are often overlooked because maintenance by users is not a priority for the industry (see Chapter 1.5) and because users are not involved in the design process. By using a Design-for-DIY approach, it becomes possible to design for the pleasure of the process.

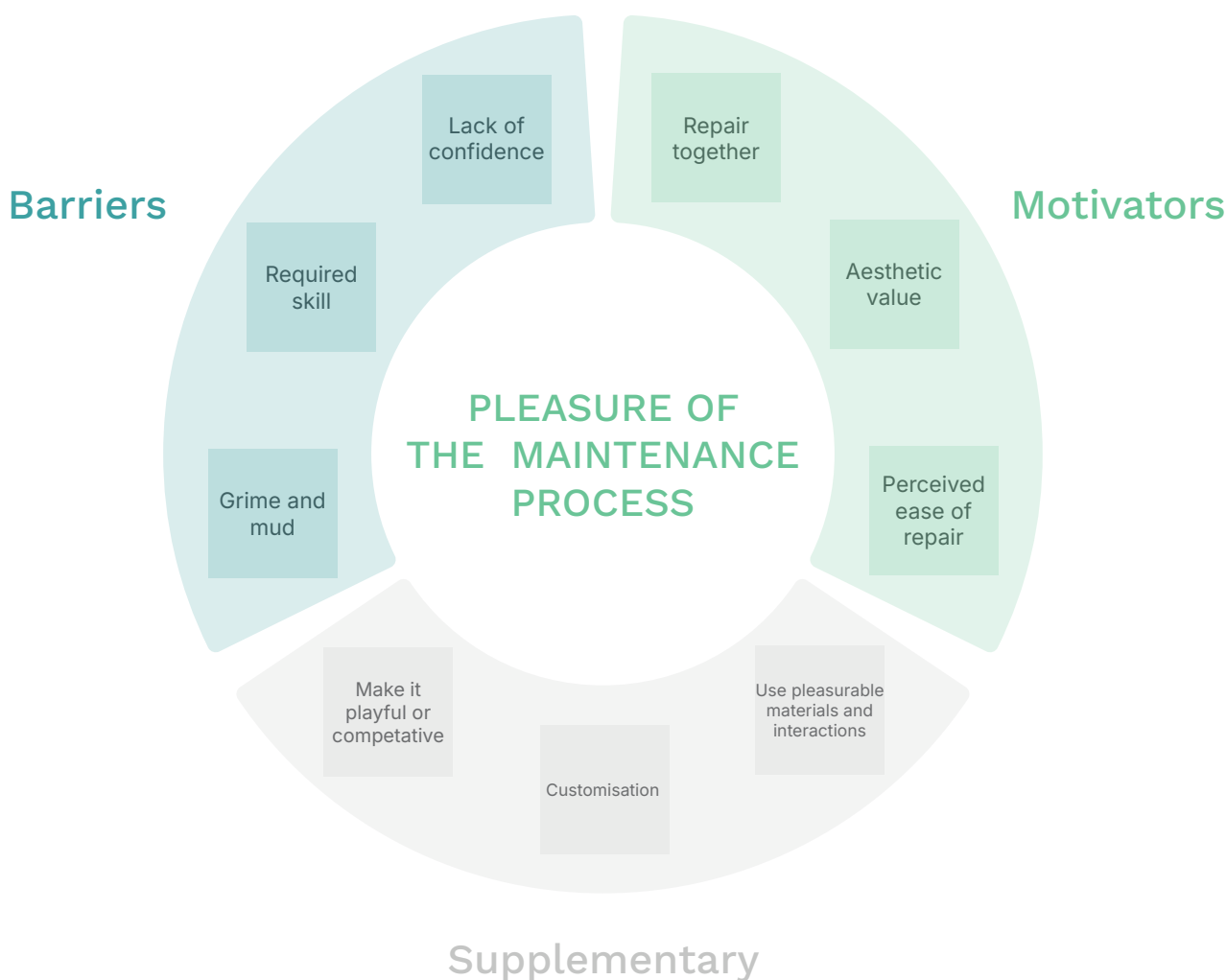


Figure 24: Pleasure of the maintenance process model

## 5.3 Creative maintenance

Maintenance is typically not considered to be a creative process. The goal is usually to bring the product into its original state. At the same time, making (customisation) was found to be more effective in creating product attachment, because of this creative aspect.

Making has several advantages over maintenance. When people are able to personalise their product, it becomes more unique. Additionally, making can be made into a much more pleasurable process. The main reason is that the process can be controlled because you are working with new materials and processes. Similar to IKEA furniture, where parts fit neatly together, the process of making parts can be streamlined to a high degree. This allows the designers to adjust the level of difficulty to the skill level of the 'maker'. Lastly, making offers the possibility to use unfamiliar machines that can make the process more interesting and enjoyable.

The opportunity arises when these two concepts, making and maintenance, are combined. This can solve the problem of pleasure during the maintenance process while simultaneously giving customisation a more functional purpose. By making spare parts, there is an opportunity for customisation that maintenance doesn't usually offer. When the parts are then installed, the whole bike becomes more unique. Finally, making also has the potential to give an early feeling of success before putting the parts on the bike. A successful making process can give people the confidence that they need to finish the repair.

During this project, I came across multiple examples of creative maintenance. The following products show that it is possible to make repair and maintenance more creative, even if the parts have certain technical requirements. Nicolas Vischi proposes to 're-pair' our products. "Functional parts of products can become the base for something new" he says (How Can We 'Want the Unwanted'?, n.d.).



Figure 25: Examples of creative maintenance  
- Shoe by 'archive of the unbroken' at the DDW 2025 (left) RePAIR project by Nicolas Vischi (right)

I believe that this approach towards maintenance could be very effective because it plays into two different goals of this project. It improves the user-bicycle attachment while simultaneously addressing the lack of maintenance.

# DEVELOP



## 6 Project formulation

This project has started from a DIY perspective. I learned that there are many different types of DIY, and I redefined what they mean in the context of bicycle repair. This was important because these different forms can have different influences on the value that we attribute to our products. Chapter 2 concluded by saying that even for products that are solely valued for their functionality, the biggest opportunity for retention lies in creating a better user-product relationship.

Why doesn't this whole project focus on making a DIY bicycle? Firstly, by making new things, we are potentially turning old bikes into waste. It is important to focus our efforts on the bikes that are already produced because they will quickly degrade if they are not properly maintained. Bikes have historically been built to last, and we have the opportunity to extend their lives. This is also the more sustainable alternative, because repair and maintenance require fewer raw materials. In a way, saving these bikes has become the mission of this project.

Secondly, I think that making is not valued in our society enough to ask users to make a completely DIY bicycle. This requires too much time and effort, which customers are not willing to invest. However, many projects have tried this approach, and although they have succeeded in making functional DIY bicycles, the projects have not taken a considerable market share (see Appendix 10 for an overview of DIY bicycles).

But just like all these other projects, this project can create awareness for our broken relationship with bikes and have consumers rethink what a bike is and what it means to them.

### 6.1 Project goal

Following the research phase, the following design statement was proposed. It acted as the starting point for generating concepts in the following chapter:

**Design a bike-related product that makes DIY maintenance of bicycles more pleasurable, inspiring a more *long-lasting and meaningful relationship* with the products we own.**

Because this Master's thesis is part of the program for Integrated Product Design, the result needed to be embodied in a product. I want to acknowledge that there are a lot of potential digital solutions that could help aid users in the repair and maintenance process, but these solutions wouldn't allow me to use my skills in the field of product design.

Then this statement focuses on maintenance over repair. This comes from the research pointing to the role of repair in the retention decision. When the bike doesn't have enough overall value (functional, emotional, social, etc.), the chances of it being discarded are higher. Instead, by focusing on maintenance before this critical moment, there is a potential to increase the value of the bike, which makes retention more appealing.

The design statement also focuses on pleasure. This can be interpreted as the pleasure of the process. The research showed that maintenance can lead to product attachment, only when the activity is pleasurable. Similarly, making only leads to attachment when the activity is successful, or in other words, pleasurable. This shows the importance of designing interventions that influence the process.

## 6.2 Requirements

The requirements are divided into two categories that are ranked based on their importance. Firstly, there are the project goals. These must be met in order to make this project successful. And secondly, there are the research requirements. They have been shown to support the main project goals. A statement is added that will make them measurable towards the end of the development phase.

### **Project requirements** – must have

- The concept leads to prolonging the life of the Dutch city bike.
- It helps to strengthen the user-bicycle relationship.
- Make people more likely to repair and maintain their current bicycle.
- Creates awareness of the unsustainable user-bicycle relationship.
- Make people aware of the value of the commodities that we use every day.
- Teaches the user something about how bikes work.
- Provides the user with knowledge about manufacturing.

### **Research requirements** – should have

- **RQ1: Creates product attachment. (Chapter 2)**

At least 70% of test users report feeling a personal connection to the bike after interacting with the solution, measured on a 7-point attachment scale.

- **RQ2: The solution recovers or adds functional value to the bike. (Chapter 2)**

The bike is brought back into its original state or gets additional functionality by using the solution.

- **RQ3: Adds emotional value to the bike. (Chapter 2)**

At least 60% of users rate their experience with the product as “enjoyable” or “satisfying” on a post-use questionnaire.

- **RQ4: Adds social value to the bike. (Chapter 2)**

At least 60% of users say they would show, share, or recommend the product to a friend, measured via a post-use questionnaire.

- **RQ 5: Adds epistemic value to the bike. (Chapter 2)**

More than 70 % of users say that they feel a change in use, after using the product.

- **RQ6: Gives the opportunity to collaborate. (Chapter 3)**

The product supports at least one activity that two or more users can perform together.

- **RQ7: Gives a feeling of success at the start of the project. (Chapter 3)**

At least 70% of users report feeling capable and successful after their first interaction with the product, rated on a 7-point confidence scale.

- **RQ8: Makes the maintenance process more pleasurable and enjoyable. (Chapter 3)**

Users rate the maintenance experience with the product at least 1 point higher on a 7-point enjoyment scale compared to their usual process (baseline established via pre-test survey).

- **RQ9: Allows for customisation, making the bike more unique. (chapter 4)**

Offers at least one customisation option, and at least 70 % of users say that the result feels unique to them.

*The percentages in this list mean that the given percentage of users scored above average on the 7-point Likert scale (4 or higher). All these numbers were based on the relevance of these scores and the expected subjectivity.*

## 7 Idea generation and concept direction

This chapter presents the ideation phase leading to one chosen direction. The ideation phase was centred around designing for the barriers and motivators that were found in Chapter 3. By eliminating barriers and designing for the motivations that are part of repair and maintenance, a pleasurable experience can be created.

### 7.1 Ideation

Different methods were used to generate ideas. I came up with many of the initial ideas during the analysis phase of the project. While reading literature, I would often come up with ways to implement a new finding in the context of this project. I kept track of these ideas in a notepad for later reference. This form of associative thinking formed the basis of the ideation. After this phase, I used the barriers and motivations from Chapter 3 to form a structured ideation. Each finding was ideated upon in individual sessions. This allowed me to associate even further focussing on individual barriers and motivators.

Finally, I took the ideas that showed potential based on my own intuition and made small drawings to understand how these ideas might be embodied. Based on this overview, I made clusters of ideas that were targeting a similar problem, barrier or motivation. These clusters then became 5 different concept directions. For each direction, the relationship is shown with the barriers and motivators from Chapter 3.

#### 1 Easy to repair bicycle

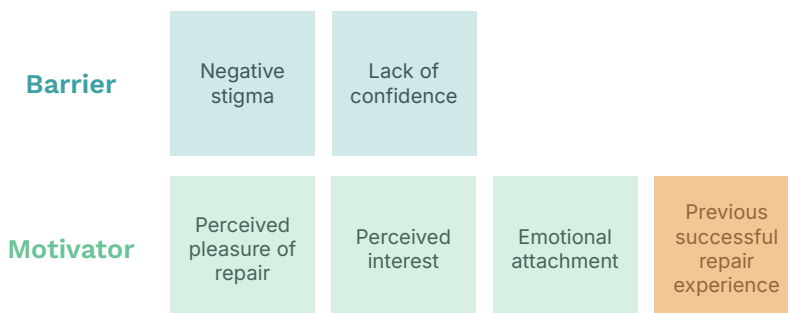
The first concept focused on the effort and time required to do the repairs, and also on the lack of availability of tools. Repair research often sees bicycles as a staple of repairability, but I suggest that there is a lot of potential to improve the ease of repair. Bicycles haven't changed much over the last few decades, and as found in the research, the industry never had a focus on DIY repair of bicycles. The industry is built around standard parts and manufacturing techniques, but by letting go of this, I believe there is potential for improvement.

The ideas included making a bike that can be disassembled with a single tool that comes as part of the bike. It also looked at a simple maintenance task like tensioning the chain and turning this into a single operation that is easy to understand. Finally, I looked at adding modularity. Not as a way to modify the bike, but as a method to aid the repair process. I noticed that people are reluctant to start a repair because they don't know if they will be able to finish the repair. If a part is modular, it can be quickly changed by a professional as a whole assembly if the DIY repair fails. This gives people the freedom to try because the user can fall back on modularity.



## 2 Making your own bike parts

This concept combines making and maintenance in a new way, as proposed by chapter 5. The concept revolves around machines that can be placed in the context of makerspaces or bicycle kitchens so that people can make their own parts. The idea is that these parts offer a feeling of success at the start of the project that can lead to self-confidence. In this way the making the parts can potentially lead to the repair and maintenance of other parts.



## 3 Teaching repair

A lack of confidence is often a cause of people not starting a repair in the first place. What I found during repair interviews is that many people lack the technical understanding of how certain bike parts work, which can lead to uncertainty. Then there is also the problem that some parts don't work as they are supposed to because of extreme wear. The user is left feeling like it is their fault that the repair is not working. This concept focuses on teaching how bike parts work away from the bike. It shows different ideas for educational materials that people can use to understand how their bike works without being worried about a failed repair.



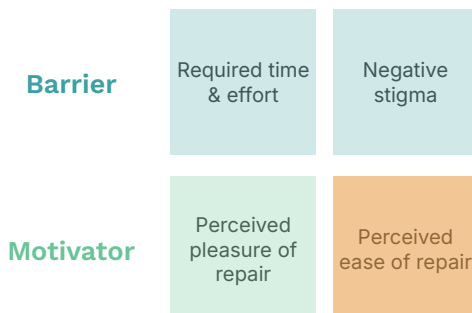
#### 4 Bike wash

Why do we have installations to wash cars and not our bikes? I think this shows how much we value bikes compared to cars, but it is not this issue that I would like to address. Instead, I found during interviews that dirt and grime can have a significant impact on the pleasure in the repair process. Cleaning would thus be an easy way to make the process more enjoyable.



#### 5 Making repair more enjoyable

This concept was informed by the frustrations that I have with repairing myself. One of them is losing parts or forgetting in which order they came off the bike. In addition, I'm often looking for videos online to understand how something works. This could be solved by creating a list with curated videos. This could be distributed through a website or a physical means like a poster or tool roll.

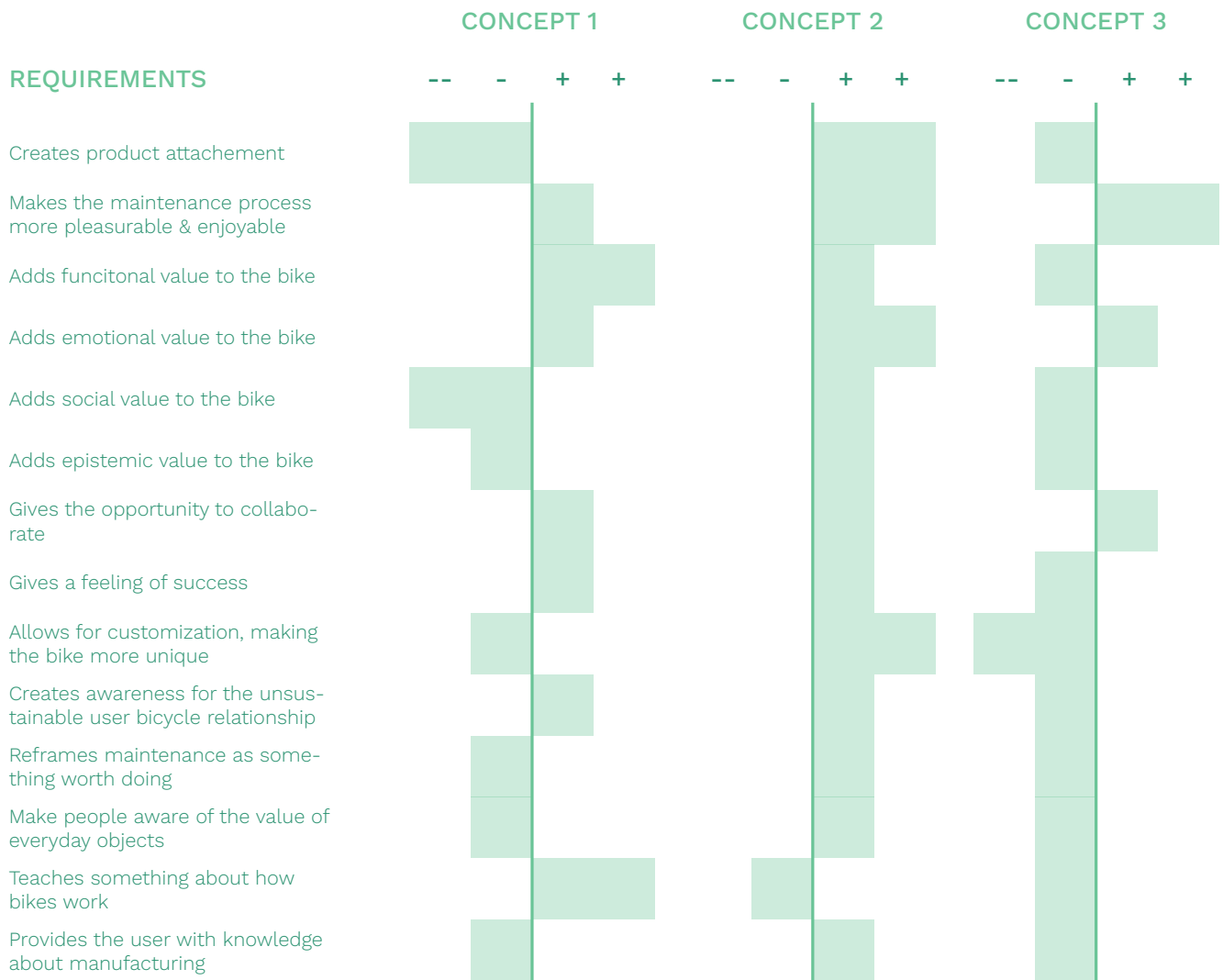




## 7.2 Concept selection

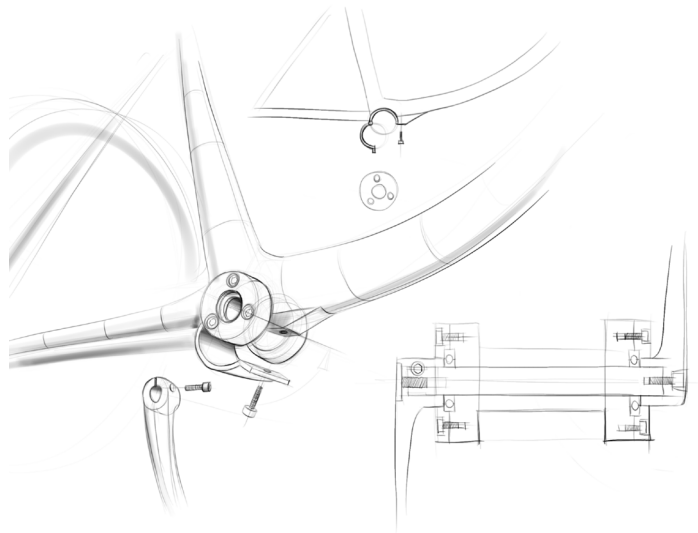
After matching the barriers and motivators with the different concept directions from the previous paragraph, I noticed that some were more focused on taking away barriers and others on motivating people to repair and maintain. I decided to focus my attention on the motivation aspect of repair and maintenance, which made concept directions 1, 2 and 5 the most promising.

Within each direction, one concept was chosen based on the size of the project and whether it would lead to a comprehensive design process (making, user testing, etc.). A Harris profile was used as a method to validate the concepts. Because it is impossible to predict the effect of these concepts on the project requirements, they are left out of this evaluation. To what extent these concepts satisfy the requirements can only be tested with a working proof of concept and user testing.



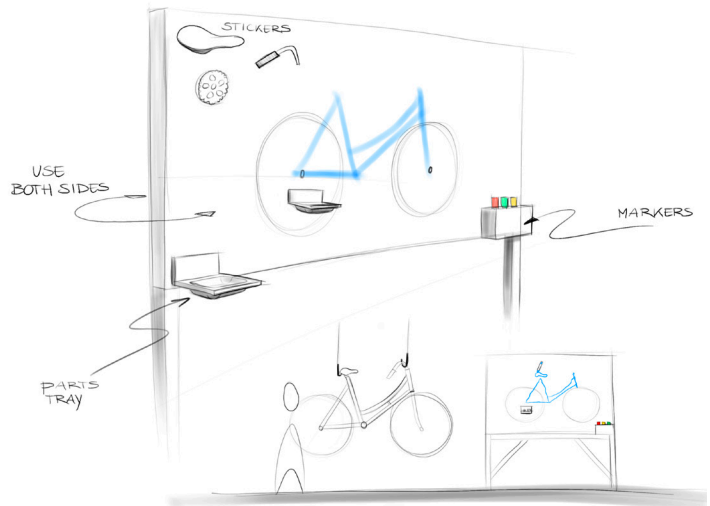
### CONCEPT 1

Concept 1 is a concrete example of how to make a bicycle more repairable. The drawing shows a modular design for a bottom bracket. This part is often too difficult and time-consuming to repair. Therefore a broken or worn-out bottom bracket often means that the bike gets replaced. The concept simplifies the disassembly process to work with a single tool, and the part can be removed entirely when repair is not possible or when the layman gets stuck during the repair.



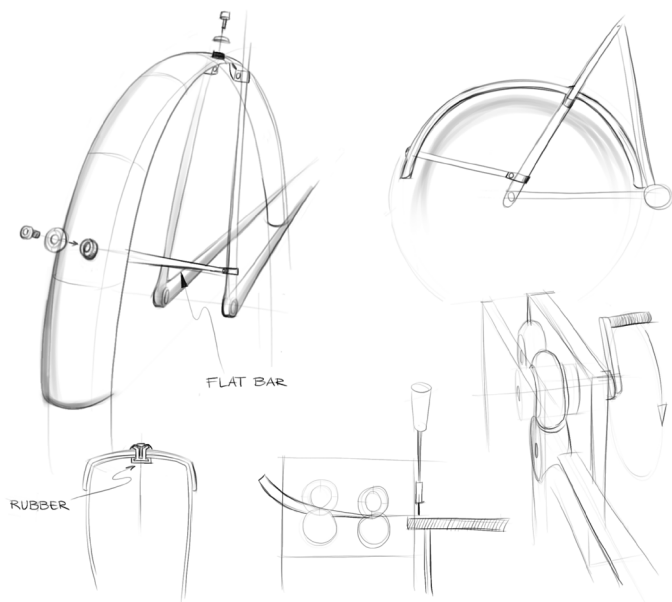
### CONCEPT 2

The second concept shows a machine to make a fender. This is a concrete example of how users can make their bicycle parts. By cranking a wheel, a strip is rolled into shape. The goal is to make the process of replacing a fender more interesting and enjoyable, and to create an incentive for people to maintain their bikes.



### CONCEPT 3

Concept 3 focuses on making repairs more enjoyable. One of the things that can be annoying for anyone taking on a repair is keeping track of the fasteners and where they came from. This whiteboard allows the repairer to place the nuts and bolts exactly where they were retrieved and allows people to add small notes to remember in what order they should be attached.



## 8 Concept - Making spare bike parts

This chapter describes the vision for the chosen concept in terms of the product and the context. This is followed by an examination of the potential boundaries that are associated with the concept.

### 8.1 Concept vision

Imagine a machine that allows you to make your own bicycle parts. You use your own power to make something that is completely yours and unique. You can see how the part is formed, and you are surprised by your own abilities. Would it be possible to make bicycle parts in this way?

The vision for this project was based on a metaphor, a coin press. You can often find these machines at famous sights. The machines allow you to turn a penny into a memory of your trip, and it often attracts kids because they can make something themselves. They can shape something that feels solid and un-mendable into a souvenir. There is something mesmerising and pleasurable about the process. For that reason, this machine became the metaphor, continuing with my project.

Metal rolling, a process used to form metal, would be perfect to support this metaphor. A flat strip of metal is inserted on one side, and on the other side, you get a finished fender. This concept offers a feeling of success at the start of the process. The idea is that people can gain confidence in their own abilities. A previous repair is the best indicator of whether people want to repair again. The idea is that after you have tried this process, the confidence and self-efficacy can transfer over to other repair tasks.

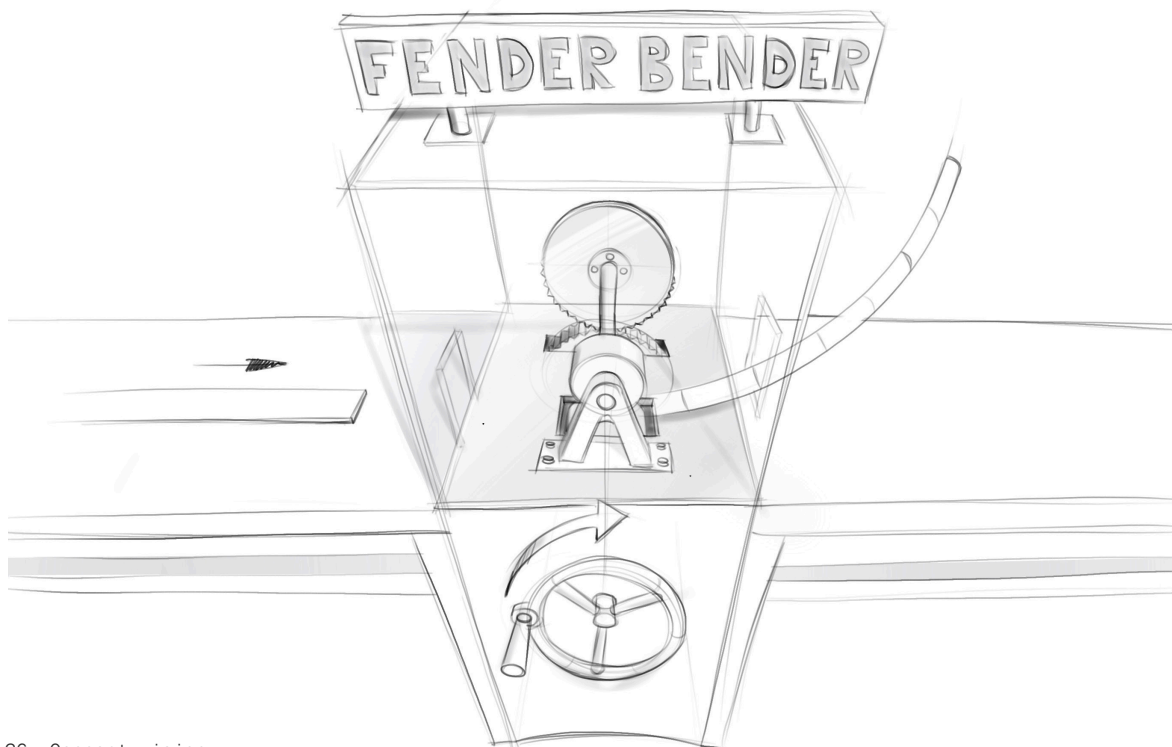
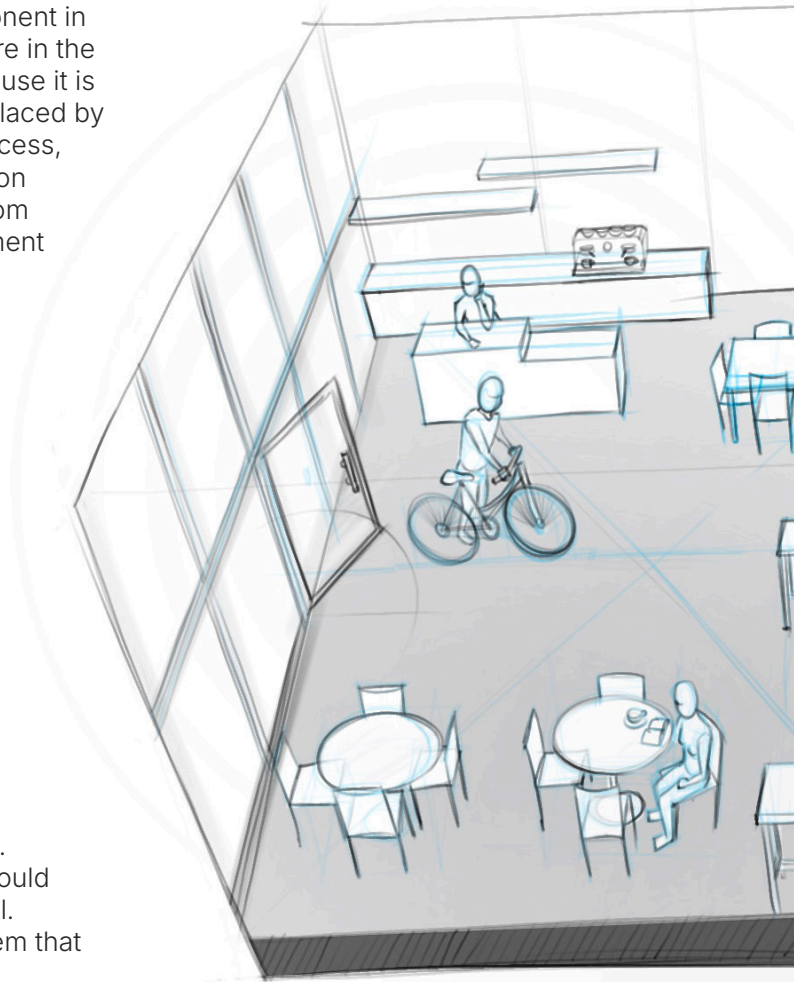


Figure 26: Concept vision

This concept also leads to product attachment in multiple ways. Firstly, you create a fond memory of repairing your bike. You can also show other people what you have made. This gives the repair more social value and can give pleasure in using the product. Making the parts yourself allows for the opportunity to customise your bike. This makes the bike more unique, which can increase emotional value. Once you have installed the part, you become part of the story of the bicycle, which can lead to product retention.

This concept combines making and maintenance in a new way, as proposed by chapter 5. A key component of this whole concept is the pleasure of the process, because research has shown that for both making and maintenance, this is a key component in creating product attachment. It was found that pleasure in the maintenance process is often difficult to achieve because it is inherently unpredictable. Because maintenance is replaced by making, the designer has more influence over the process, and the level of difficulty can be changed depending on the user. By using a metaphor that some recognise from their childhood, the process is associated with enjoyment and pleasure, and has the potential to change our perspective on bicycle repair.



### An open-source ecosystem of machines

Part of the vision is that these types of manufacturing processes could be applied to other parts of a bicycle. Next to a machine for making bicycle fenders, there could be machines to make a chain guard, pedals, and a bell. This could turn into a family of machines. An ecosystem that enables people to take care of their own bikes.

I drew a lot of inspiration from the Precious Plastics project. Their goal is to find a solution for all the plastic waste in the world. They have approached this by enabling workshops and makerspaces to build their own small-scale plastic processing machines. Precious Plastics is a non-profit that has made its plans completely open-source. The company is trying to solve a 'wicked problem', not by selling a product, but by enabling people to take action. I believe that solving bicycle maintenance falls into a similar category.



Figure 27: The Precious Plastics basic machines ecosystem

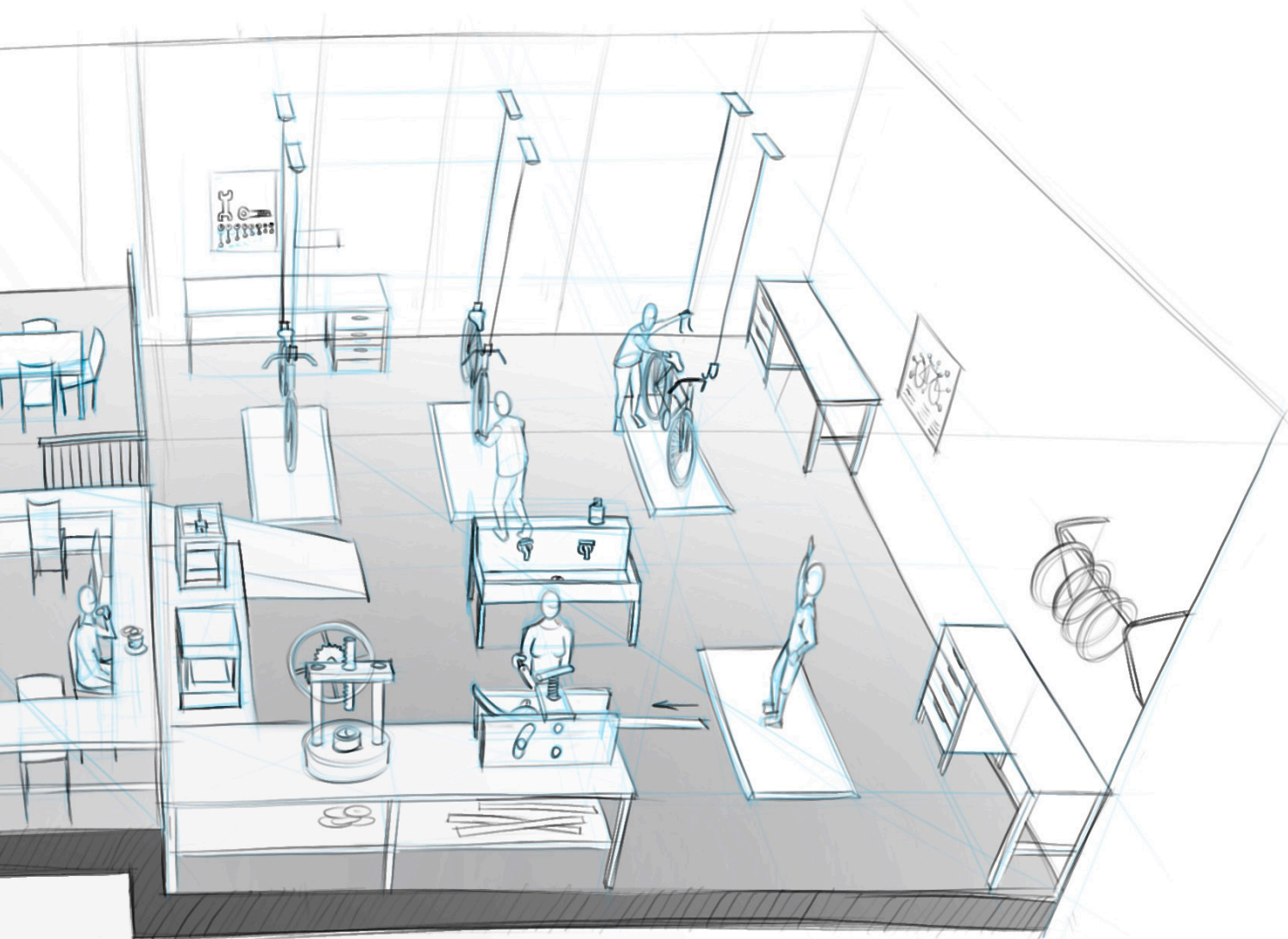


Figure 28: Concept drawing workshop

## Context

Where would this concept reach the most people? The analysis phase highlighted the importance of repairing together or in an environment where other people are repairing as well. Bicycle kitchens, which are described in Chapter 1, can provide this environment. It is a markerspace that is focused on repairing bikes. The reason to go here are because you can save money on repairs, and because there are people who can provide guidance when you get stuck.

This would be a perfect place for these machines because these places already have people with technical knowledge. There also needs to be someone to maintain the machines and repair them if they break.

This bicycle kitchen should preferably be located close to a train station. Stations are often located centrally in Dutch cities, and they are a place that people often pass on their way to work or home. The location can be a big barrier to participation, so it is crucial for this concept.

In the concept drawing, you can see that the workshop is combined with a coffee place. A survey among 4000 bike shops in the US showed that around 12% of bike shops have in-house coffee bars ('US Bicycle Market 2013', z.d.). I believe that this trend can potentially make bicycle kitchens more approachable and market them as a place to meet. You can wait with a coffee until a workspace becomes available, or you can work from the café if your bike breaks down unexpectedly. The workshop environment is crucial to give the concept exposure and to lower the barrier to entry.

## 8.2 Boundaries

By focusing on making instead of reducing the barriers to maintenance directly, there is a chance that more barriers are created. According to Ackermann (personal correspondence), designers should be careful with introducing new barriers to product care. The following are potential barriers that need addressing:

- **Unfamiliar machines:** Using new machines and techniques can both lead to interest in maintenance as well as fear for some people. The new machines then become an extra barrier. The machines should therefore be approachable and easy to use.
- **Creativity:** Making allows for customisation, which is critical for increasing product attachment. At the same time, creativity can also form a new barrier. It is therefore important to make the customisations easy and not force people to be artistic. There should be options to make the parts unique without much effort. Interestingly, IKEA furniture sets are not creative. People follow clear instructions without any form of creativity in the process. This shows that creativity is not necessary for attachment through making.
- **I'm not a maker:** Making allows the designer to have full control over the process. This means that the skill level can be adjusted based on people's experience. The problem is that 'making' is often perceived as something that requires a similar amount, or even more, skill than repair.

Even after addressing these barriers, there is a chance that the project will only appeal to people who are already interested in DIY. With the approach taken in this project, I've tried to emphasise that focusing on removing barriers is not enough; we also need to change the motivations to maintain our products. Only in this way can we reframe what maintenance is.

I think that the context is crucial in the adaptation of the concept. Both in the form of the physical context as well as the culture surrounding repair. People shouldn't have to go out of their way to make use of the product. Secondly, the project needs to be adopted by our culture. Marketing campaigns will play a big role in this. Maintenance needs to be seen as something that you take pride in. This will not be achieved with this project alone, but it can help to change the narrative.

## 9 Research through design

This chapter starts by introducing the most important insights from the analysis phase that were used as starting points for prototyping. It continues with choosing appropriate DIY manufacturing techniques and parts based on certain criteria. Three parts were prototyped simultaneously, and a chain guard was chosen for further development into a workshop. Both the workshop and the part were improved based on feedback from users.

Finally, the research through the design process will test the feasibility of the concept by considering the following three aspects: 1. If it is possible to make DIY universal bicycle parts that meet durability requirements, 2. If the process of making the parts can be made pleasurable, and 3, to find out if it would be possible to turn this into an open-source platform driven by a family of machines.

### 9.1 Starting points

The main design driver for this phase was the pleasure of the process. Designing for pleasure has an influence on all aspects of making and differs greatly from person to person. Only by working closely together with users during the design process is it possible to design for this.

The other starting points for this chapter were based on the analysis phase and together led to the following list:

1. The making process should be interesting to attract users.
2. The environment should encourage people to work together.
3. Machines need to be safe and easy to use.
4. Parts should have similar characteristics in terms of functionality and durability as the original part.
5. Different forms of customisation should be explored.
6. Show people how parts are traditionally manufactured.

These starting points, together with the findings from this chapter, will form a set of guidelines that can be used in the future by other makers to design parts that follow the same philosophy.

### 9.2 Evaluation of suitable manufacturing techniques

In order for the concept to work, the parts need to be manufactured in a non-industrial setting. This brings along many challenges. Some production techniques that are very common are not possible anymore because the method relies on heavy machinery. In this chapter, a study was done into the machines and manufacturing processes that are common in a makerspace environment, which were then compared with the relevant starting points to get an overview of suitable techniques.

#### **Makerspace inventory**

This project was executed in the faculty workshop at IDE (the PMB). It therefore acted as a first frame of reference for machines that would commonly be available in a makerspace. This shop is equipped with all the common tools and sometimes even more professional versions of the tools you would find in a makerspace. An overview of the tools can be found below. The method of weighted averages is used to rank them in terms of their alignment with the project goals. The scores are based on my own experience with using these machines.

Of course, the project is not limited by the machines that are already inside the makerspace. The Precious Plastics project shows that with limited tools, new machines can be created that are suitable for small-scale manufacturing. This is only a starting point for machines that would be suitable for the project, and further research will show if other options should be explored.

		Perceived pleasure	Perceived interest	Ease of use	Safety	Processing speed	Total
	Weight factor	20	20	15	30	15	100
PROTOTYPING	FDM 3d printer	1	3	3	4	2	275
	SLA printer	1	2	2	2	1	165
	Laser cutter	1	4	1	2	2	205
	Vacuum former	5	4	4	3	5	405
	Foam cnc mill	1	3	1	1	2	155
	Foam cutter	5	3	5	4	5	430
	Plastic bender	4	2	5	4	3	360
	Sheet metal cutter	2	1	5	3	5	300
METAL WORKING	Bench shear	2	3	5	5	5	400
	Bending brake	2	3	5	5	5	400
	Metal bend saw	3	2	4	3	4	310
	Hole punch	4	4	4	4	5	415
	Leaver plate shears	1	2	4	5	5	345
	Metal roller	4	3	4	5	5	425
	Spot welder	4	4	3	3	5	370
	Bearing press	2	1	5	5	5	360
MACHINING WOODWORK	TIG/MIG welder	2	4	1	1	2	195
	Drill press	1	2	3	2	3	210
	Band saw	2	2	2	1	4	200
	Disc sander	2	1	5	2	4	255
	Spindle sander	2	1	5	3	4	285
	Scroll saw	2	1	4	2	4	240
	Mill	3	5	1	1	1	220
	Lathe	2	4	1	1	1	180
HAND TOOLS	CNC Mill	1	5	1	1	2	195
	Hand drill	2	2	5	3	4	305
	Dremel	3	2	5	3	4	325
	Jigsaw	2	2	4	3	4	290
	Palm sander	1	1	5	4	3	280
	Gluegun	1	1	5	5	4	325
	Hand saw	1	1	5	5	3	310
	Sewing machine	3	2	3	4	2	295
	Sand blaster	3	4	5	5	5	440

Figure 29: Evaluation of prototyping techniques using weighted averages

Forming and moulding processes seem to be the most effective at creating a pleasurable experience while making. I think this can be attributed to two reasons. Firstly, both these processes give a relatively quick result. The part takes shape in front of your eyes while the machine is doing the work, or you get to uncover the result. Outside of a production environment, we are more used to parts slowly taking shape in the form of subtractive manufacturing. This is far more time-consuming and less mesmerising. Furthermore, there is an unfamiliarity with the material properties of, for example, plastic and metal. Both these materials are often experienced as non-mendable. This makes the manufacturing processes for these materials more surprising and more pleasurable.

In conclusion, there are only two categories of processes that would fit the requirements of this project. These processes are forming and moulding and will be used as starting points in the prototyping phase. Because the processes were rated based on personal experience as a student assistant in the workshop, further user testing should be done to find other suitable processes.

### 9.3 Part selection

The concept relies on being able to maintain your bike by making DIY bicycle parts. Maintenance, as defined by this report, means taking care of or repairing non-critical parts. These parts contribute to the feeling of degradation but don't require users to take action.

When mapping out all the parts of a bike, I found that almost all the non-crucial parts were specific to city bikes. There is a small category of essential parts that don't require immediate attention when they degrade. This category includes the handlebars, saddle and pedals. The handlebar grips and saddle can degrade over time, causing them to tear, and the pedals can wear out before they need replacement. The wheel could also fall under this category, because a wheel that is not true doesn't require the user to take action, but because of its complexity and mechanical function, it is difficult to make with a DIY process. This narrows down the scope of potential parts that would fit this project.

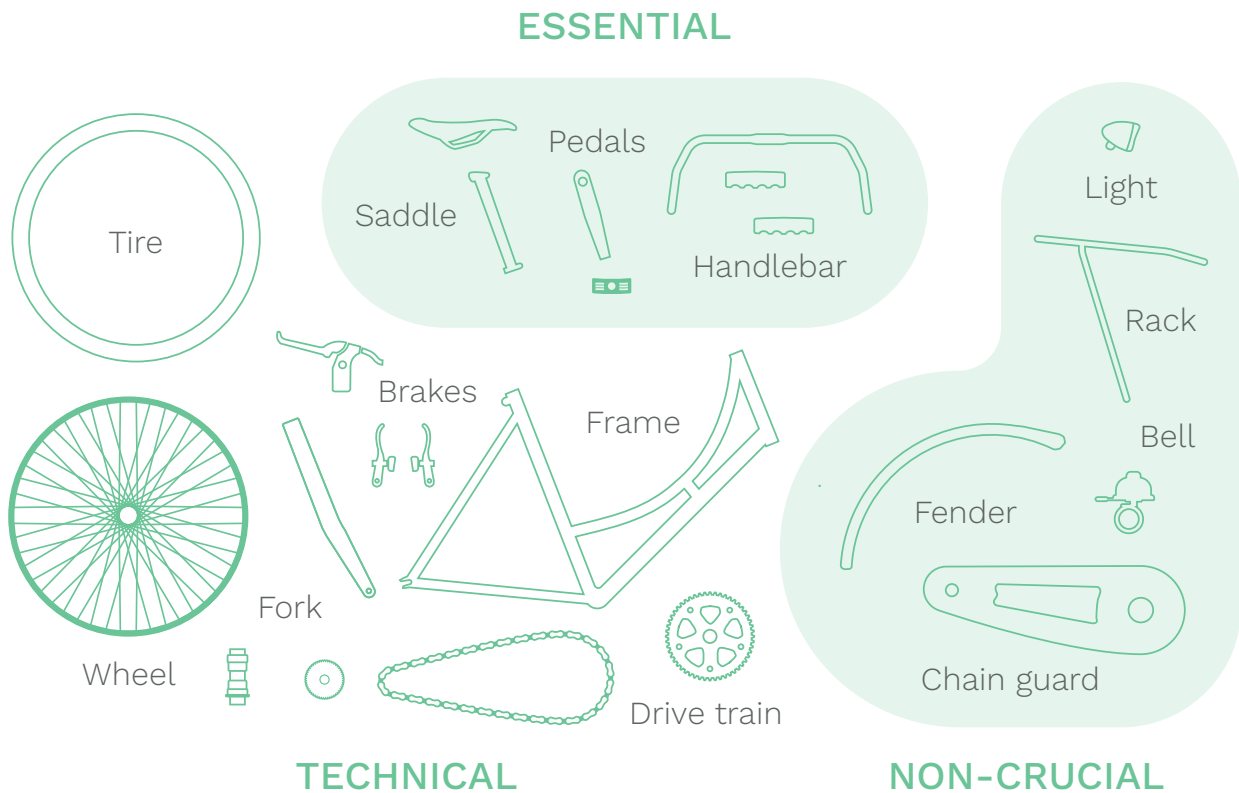


Figure 30: Bike parts divided into three categories

I then did desk research to see if there were people who had already made DIY versions of these bicycle parts. I looked extensively on Instructables, Pinterest and YouTube to give an overview of existing DIY projects. An overview of these projects can be found in Appendix 3. The number of projects found per part gave an indication of the feasibility of making the part in DIY

The table below shows an overview of the bike parts ranked, based on three categories: How much they contribute to a feeling of degradation, their fit with the chosen production processes, and how common it is for this part to break. This last category was checked by looking at 100 bicycles and marking how often these parts were broken.

PARTS	FEELING OF DEGRADATION	PRODUCTION PROCESS FIT	CHANCE OF BREAKING
Saddle	● ● ●	●	● ●
Handlebar	● ●	●	●
Pedals	●	●	●
Rear rack	● ● ●	●	● ●
Chain guard	● ● ●	● ● ●	● ● ●
Fender	● ● ●	● ● ●	● ● ●
Lights	● ●	●	● ● ●
Bell	●	● ● ●	●

Figure 31: Choosing bicycle parts to prototype

Based on these findings, three products were chosen to be further explored. The three products are a fender, a chain guard and a bicycle bell. The first two were mainly chosen for their fit with the chosen production processes and because of how often they break. These products also contribute to a feeling of degradation because of the annoyances they give. The bell is the least essential of all the parts, and therefore contributes less to a feeling of degradation. It was chosen to see if making a non-essential part could have the same benefits towards retention as the other parts.

## 9.4 Prototyping three different parts and their making process

This paragraph describes the prototyping process of three different bicycle parts and their manufacturing process. All the decisions that were made are carefully described, concluding the insights from the process. Three prototypes were developed simultaneously to be able to make a claim about the feasibility of the whole concept. Three questions need to be answered for this:

1. Is it possible to make durable DIY bicycle parts for city bikes?
2. Can the making process be made enjoyable and pleasurable?
3. Would these parts suit themselves to an open-source concept based around a set of machines?

All three parts started with the aim of replicating the original manufacturing technique in a DIY makerspace setting. The reason for this was the opportunity to show how parts are traditionally made (starting point 5). In the next paragraphs, you will find a workshop log describing the prototyping process.

### 9.4.1 DIY Fender

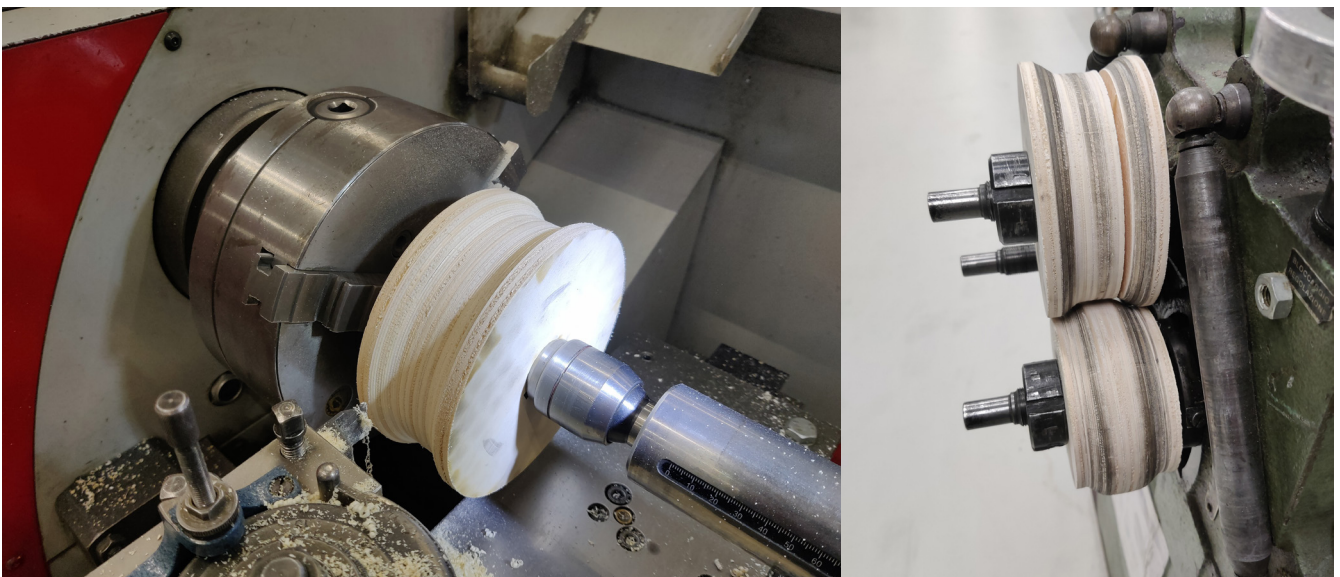
The fender is what originally brought along the idea for this concept vision. It builds on the metaphor of a coin pressing machine. The question is, will it be possible to make a mudguard by hand-cranking a wheel? And can I make a machine that can do this? A video of a production site in India gave me the impression that no high-tech machines are required.



Figure 32: Roller bender in use to make a metal fender (Manufacturing Process Skills, 2025)

### Roll bending a metal fender

The process started by getting a feel for the material and the production process. I did this by using the roll bending machine in the workshop. In order to get a desired profile for the fender, I made custom profile rollers out of laminated plywood. They were turned on the lathe and then tested on the machine. I tested both aluminium and steel in several thicknesses (0.5, 1, 1.5, and 2 mm). The material of 1 mm and smaller was cut from a large sheet, and the thicker pieces were stripped and manufactured using a rolling production method.



The rollers functioned well for the thinner pieces that were cut from a sheet, but the rollers broke after trying the 2mm thick strips. The rollers separated on one of the veneer layers of poplar plywood, which was to be expected given the quality of the material. The following insights were gained from this test:

- Plywood is not strong enough to act as rollers
- 2 mm thick material is both technically difficult and aesthetically undesirable for a fender
- The material has the tendency to 'wander' when being fed into the machine by hand. A guide is necessary to solve this.
- The curvature of the piece changed based on which roller was driving or being driven. The machine has three positions for rollers. Two are being driven by a powerful electric motor, while the third one is guided by the material. This changed the curvature of the fender towards the sides or away from the sides. This likely happened because the rollers were designed to have the same distance from the top of the fender to the centre of the roller. This means that the sides (because they are further away from the centre of rotation) are moving either faster or slower based on which wheel is driven and driving. If this hypothesis is correct, it could be used to bend the material in the favoured direction.



Figure 34: Testing the shape of the rollers

After these tests, I wanted to know how much force was required to bend the metal. I decided to make a simple machine out of 2×4 lumber and 3d printed parts to see if hand power would be sufficient. The rollers were 3d printed with 40 % infill, of which one was connected directly to a crank using epoxy. The configuration of the machine also changed from a pyramid-type system to a pinch-type system.

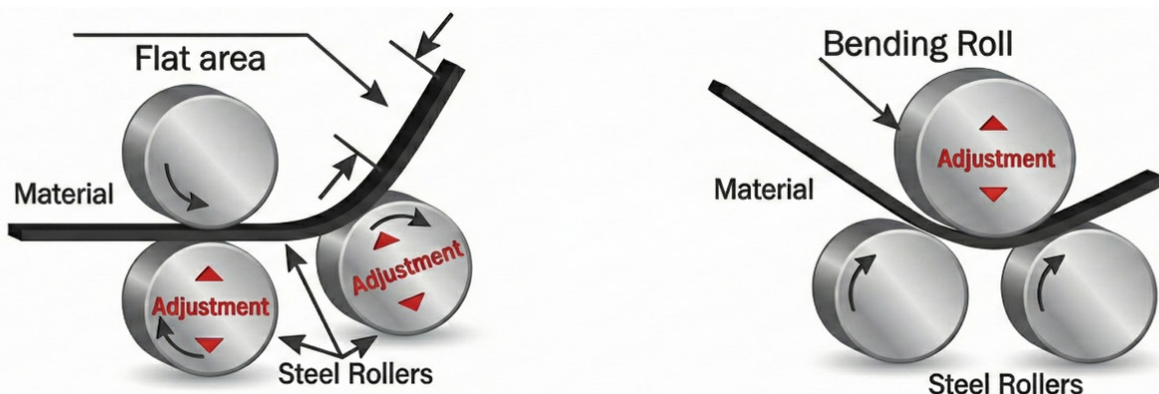
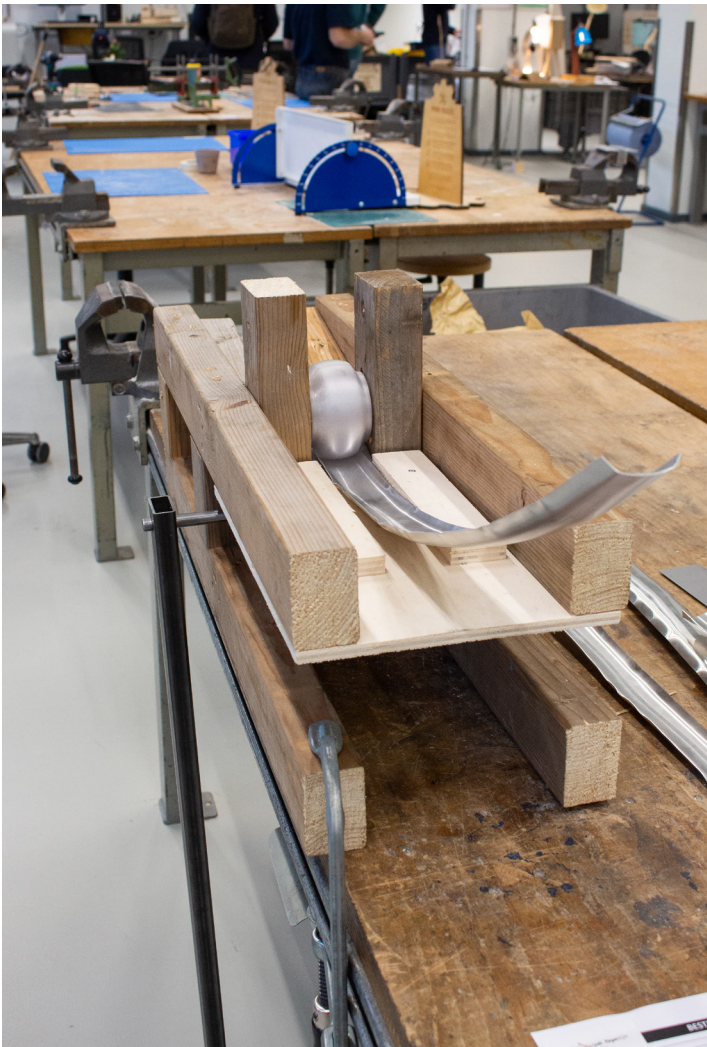
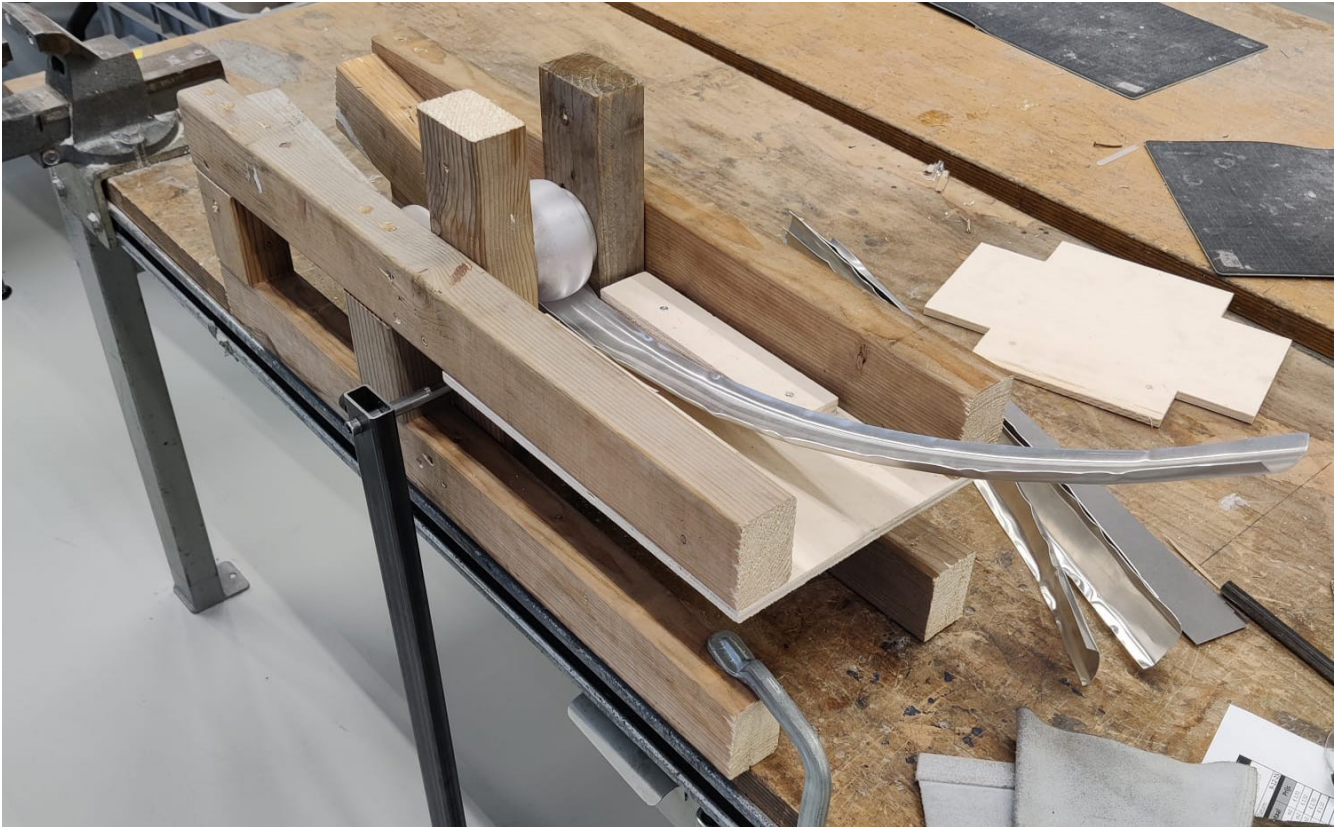


Figure 33: Two different types of roller benders: pinch-type system (left) and a pyramid-type system (right).

# DIY Fender roller machine



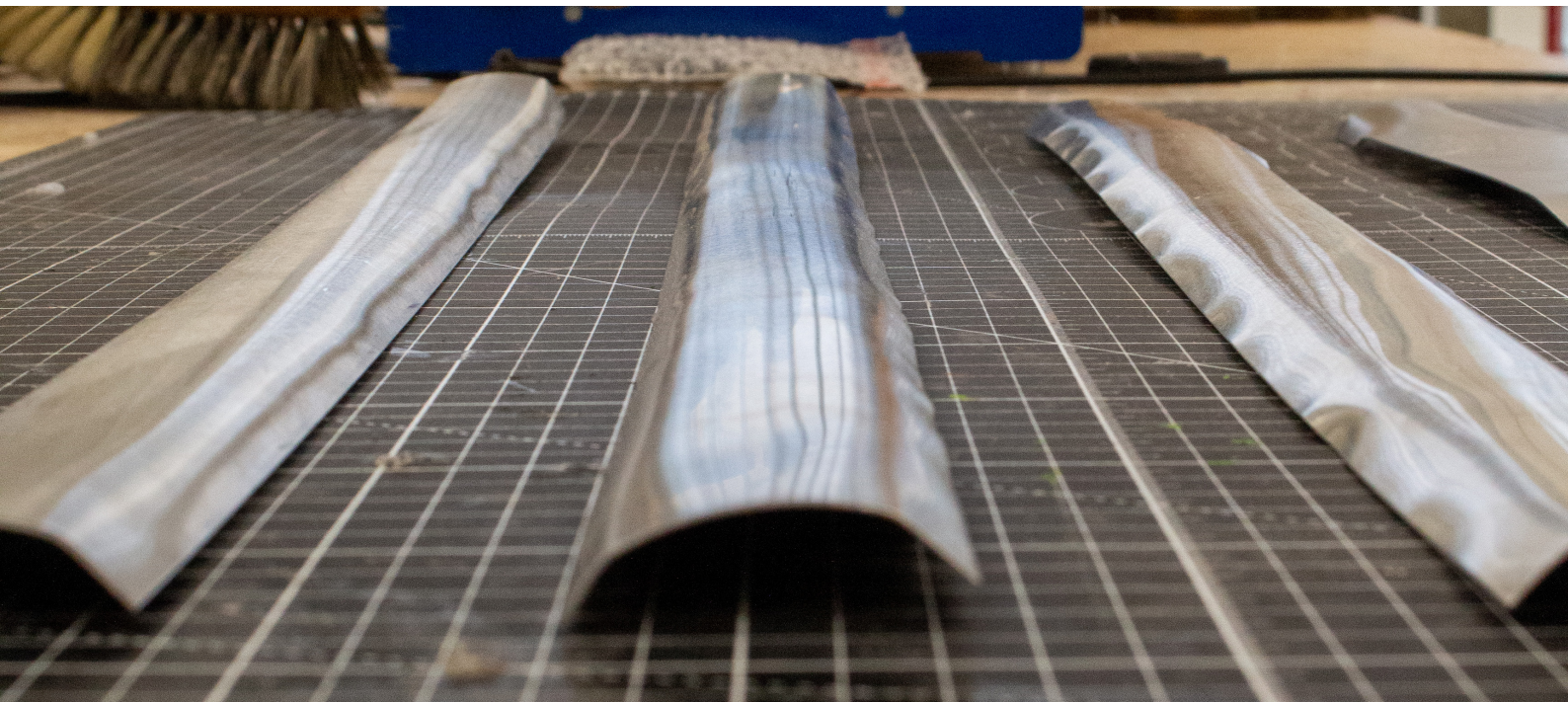
Using this machine, I got the first results that started to look like a fender. I did have to increase the angle of the adjustable roller gradually, taking several passes. I tried different thicknesses (0.5, 0.75 and 1 mm) aluminium sheet cut to the exact width. This gave me varying results, but all the fenders had a characteristic 'wrinkling' along the edges. This is a result of buckling along the edges and is caused by the material being bent in two directions. The curved profile, together with the curve necessary for the fender, creates a convex shape where the material is stretched along the top, or flat part of the profile, and compressed along the edge. The material needs to be displaced, and it starts to buckle where it is free to move. I was also not able to reduce the radius of the fender because of this problem. The buckling made it impossible to turn the rollers. This experiment gave me many insights and ideas to improve the prototype:

- The distance between the rollers is crucial. Any space left will result in buckling along the edges. To improve, the rollers need to be made from a tougher material than PETG, preferably steel, and the distance between the rollers should be adjustable.
- It was difficult to push the material into the machine. I could make a system with another guiding wheel that is connected to the rollers and that pushes the strip into the machine at a constant speed.
- The problem with turning the crank could be solved in multiple ways. Firstly, the friction forces should be minimised by adding bearings. Bearings will also allow for better control of the roller position and prevent the shaft from deflecting in the wooden bearing surface. And secondly, a gear ratio could be added to increase the output force at the roller surface.
- The buckling starts at the moment that the strip hits the deflection roller. To prevent this, I could potentially pinch the fender here as well by turning the single roller into a roller pair.
- Lastly, the shape that was chosen for the profile creates stress concentrations at the folding line. By giving the cross-section a continuous curve, the buckling could be reduced.



Figure 36: DIY fender roller machine prototypes

Figure 35: Buckling along the edge of the fenders



According to the workshop expert (D. van Eden, personal communication, January 20, 2026) making fenders is seemingly easy, but requires a tremendous amount of force and precision. In a normal roller the profile is shaped in a way that the middle part is compressed making it stretch out more. At the same time the edges are folded over using a special tool to prevent buckling. I wouldn't be able to make the machine's frame stiff enough out of wood if I wanted to achieve this. Based on this advice I decided to pivot to another approach. The people in the workshop had suggested to roll a thin walled tube and to cut it open afterwards, but this didn't fit the requirements. Instead of working from the most complex shape, I made the most simple fender imaginable, a flat, curved piece of aluminium. This fender was rolled using the shops roller bender and then modified to fit a city bike. The contact points were made out of 1 mm thick steel sheet, attached to the fender using rivets. This shows that a DIY fender is easily achievable, and thus more options needed exploring.



Figure 37: A flat DIY fender made from aluminium

The disadvantage of the flat fender is that it loses part of its strength and that the water is not projected downwards, but instead splashes to the sides. This reduced the functionality of the fender and could make the DIY version less desirable. For that reason, I made two new prototypes from plastic.

### PET bottle fender

This fender design takes its inspiration from the soda bottle fender. One long strip is divided into segments that are individually moulded into the right shape. The challenge with this design was to make it look professional. When you look at another PET bottle fender they look very badly put together and I think that this is not preferred for this concept. People should be surprised about their abilities and this comes from a well-executed end result. So how can the plastic fender be made more desirable? To achieve this the fender was made out of a continuous strip of transparent plastic instead of loose segments. Then the precision of digital manufacturing was used to make a clean result. The strip needed to be made out of the thermoplastic PETG, because it cuts cleanly on the laser cutter.

After cutting, the flat piece was heated at the seams using a long heating element and then formed around a wooden mould. This offered enough precision to get a straight fender. At first, a model was made without overlapping sides. The idea was that these sides could be glued together, but it was tedious to glue these parts together and not very pleasurable. The second version had slightly overlapping sides that could be welded



Figure 38: A PET bottle fender from Instructables (namatuzzi, n.d.)

together using heat. A soldering iron did this perfectly and it left a clean hole on each of the joints. This also sparked the idea of making a fender that could be pressed together using plastic rivets. I made another design that would work with plastic press buttons, but this didn't give the strength that I was looking for.

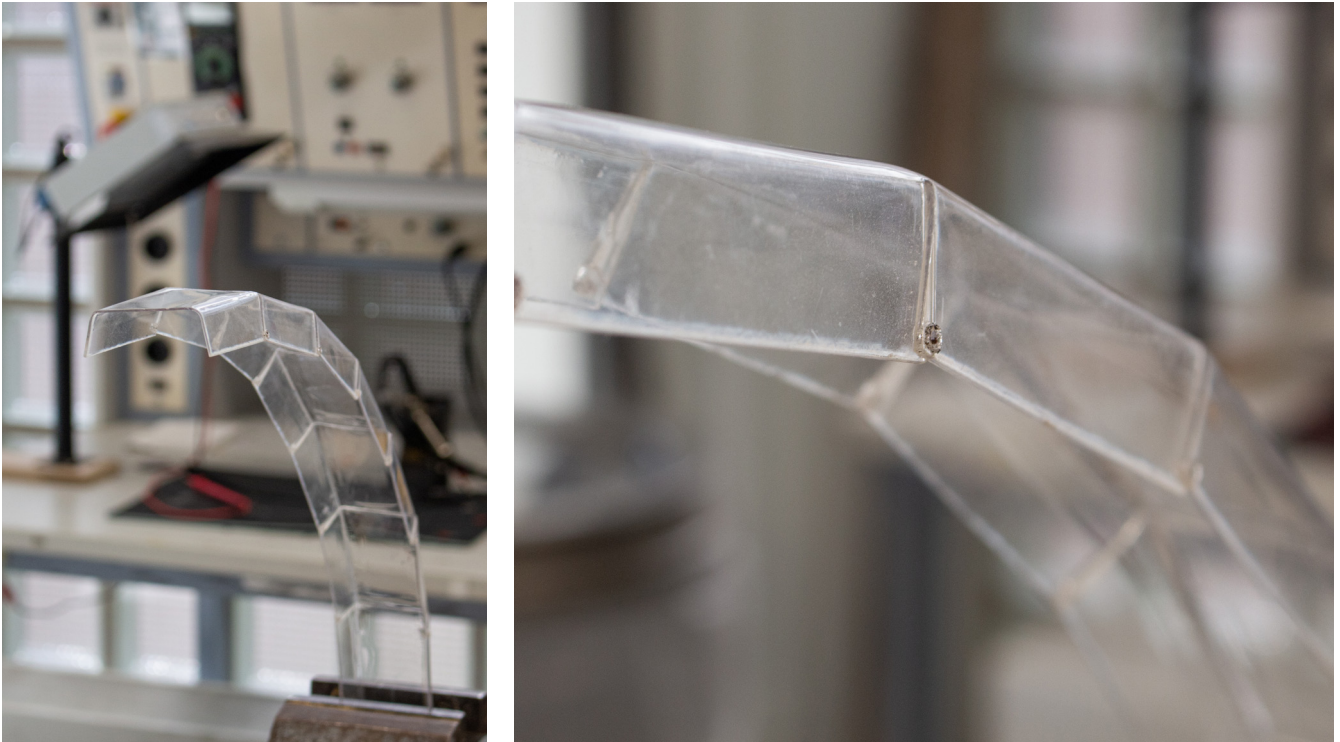


Figure 39: Plastic fender prototype with welded corners (right)

After making these prototypes I realized that the joints weren't necessary. Instead, of making the joints afterwards, the whole fender could be made out of a single strip of plastic. By heating the strip one segment at the time the form of the fender could be made. This sparked a new concept for a fender machine which I was unable to test during this project.

### Findings

The prototyping process showed a lot of challenges that come with making DIY parts. It showed that making fenders the traditional way is difficult in a DIY setting. The forces and precision required are not possible to achieve with a DIY machine. However, there are promising alternatives that can be made with plastic that can be equally rewarding for people to make.

### 9.4.2 DIY Bicycle bell

Similar to the fender, the making process of the bell started from a pleasurable metaphor. Bike bells are always formed using a mould. Turning a flat piece of metal into a 3D shape. The metaphor of kids playing with sand moulds was used. When kids play in the sandbox, they turn sand into different shapes. This metaphor was used as an inspiration during the prototyping process.

The process of prototyping a bell started in a similar fashion to that of the fender. The aim was to make a metal bell using the same production method as used in industry. What if you could press the top of a bell by just pulling on a lever? Can you make your own moulds, and can you create enough force to make this work? On YouTube, I found many examples of people using 3d printed moulds to do metal forming, so I was convinced that it could work.

### 3D printing moulds

Different 3D printed moulds were made in this process. I started with two halves made from 3D printed plastic with a gyroid infill pattern of 40 %. These were placed underneath the bearing press in the workshop. To align the two halves and to prevent the blank from wandering, all the parts had a corresponding hole with a bolt. The first test was promising. The mould, printed in PETG, didn't show any indents, and the bell got its shape with slight wrinkles along the edges. The shape is very important for the tone of a bell, so I needed to do more experiments to get rid of the wrinkles and to increase the outside curve.



Figure 40: The first prototype - A bell made with 3d printed moulds

For the next iterations I tried moulds that formed the bell in multiple steps. I tried different materials and coating the moulds in Vaseline to reduce friction, but they all gave the same wrinkles at the edges. At the same time I was coming up with ideas to customize the bell and I came up with a flower shaped bell. I wanted to know if this would still create enough sound and if I would be able to make different shapes as well. After making this I realized that by changing the shape I was directing the buckling at the edges into a new form. During the first tests the 3d mould failed and to solve this the mould 'negative' was made out of aluminium. This gave good results, but the edges were still wrinkling.

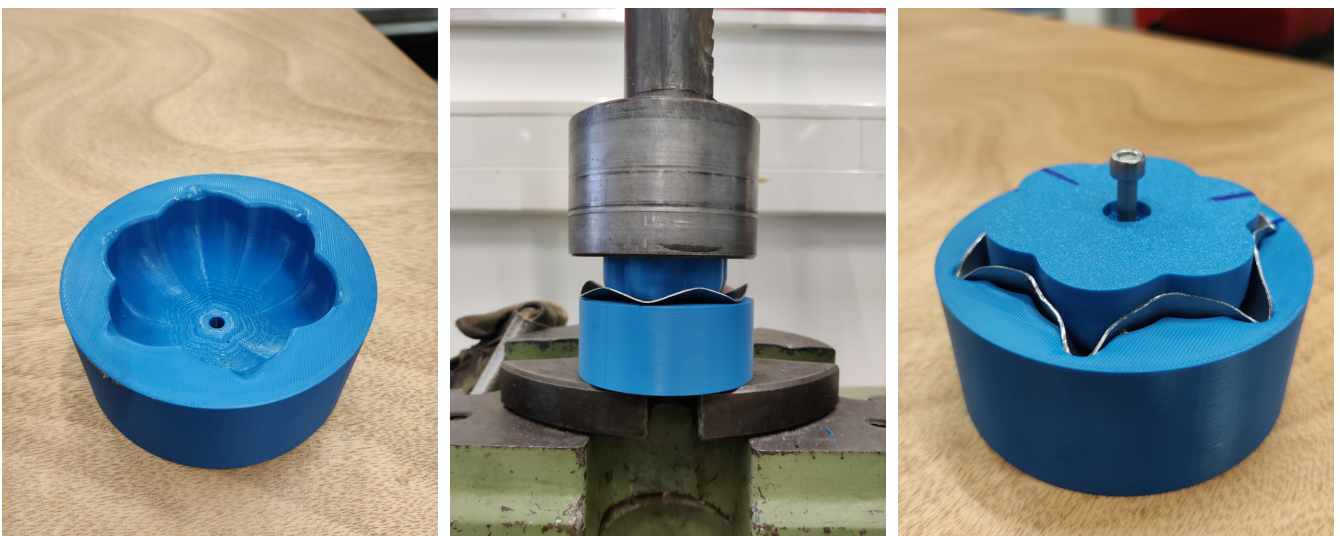


Figure 41: Making a flower shaped bell



Figure 42: Lower die made from aluminium

After getting mixed results I consulted Phoenix 3D in Eindhoven to get an expert opinion on sheet metal forming. They are specialized in rubber moulding, a specialized process that is used for small to medium production volumes. I got in contact with Theunis van Woestijne, one of their project engineers to get advice. He described three different processes and their benefits and drawbacks, see table below:

Crash forming	Deep drawing	Rubber moulding
Doesn't allow for very deep moulds and creates many pressure points in the mould.	Deep drawing only works for shapes that are convex, like a bell, but doesn't allow for more complex geometry. Deep drawing requires a lot of force	The process works under immense pressure that cannot be provided by ordinary shop machines.
It allows for complex geometries and crisp folding lines.	It creates an even wall thickness all along the part.	You only need one side of the mould.

Figure 43: Different forming techniques according to Van Woestijne

Van Woestijne (email correspondence, January 21, 2026) said that it was ambitious to achieve this type of shape using the crash forming process. In order to improve the results, I could change the type of metal to an alloy that is more suitable for forming (DC04 is commonly used), and I could also improve control over the sheet at the beginning of the forming process. Because the parts are initially formed between the points that touch the material first, you lose a lot of control. By adding a rubber ring, the sheet doesn't move while pressing.

Van Woestijne's advice opened up the world of metal selection. There are countless different alloys, and they all have their own acoustic properties. The metal alloys with higher hardness (metals with high carbon contents, for example) are better for acoustics than softer metals (aluminium) (Allan, 2018). Because of this reason, making a bell with non-industrial equipment is difficult. Instead, I decided to look at other ways to make a DIY bell that would be easier to make.

For inspiration I looked at different types of instruments that could function as a bell. The requirement is that the sound should be short and loud and preferably have a characteristic bell sound. Three instruments were found that have less complex geometry than a traditional bell, but that can still follow the given requirements. These are the pipe bell, triangle and a flute.



Figure 44: Triangle, pipe bell and flute

Both the pipe bell and the triangle can produce that is similar to a bike bell and they were therefore preferred over the flute. For the bike bell the geometry is already created by the pipe and it is only a matter of a section to get the desired result. I found an online resource for making DIY chimes that was very useful (Chime Design & Build, z.d.).

An Instructable provided the plans for the first prototype, a musical instrument with copper pipes (LivingMusic, z.d.). The pipe was supported at the nodal point (one of the nodes of the standing sign wave) with rubber bands. After striking it with other metal objects it didn't produce enough sound. The sound that a pipe bell produced depends mainly on the way that it is supported and the striker used. I continued testing different types of mounting solutions and striker materials to see what gave the best results.

## Findings

During the prototyping process of making a bell, similar problems were encountered as with the fender. Moulding metal turns out to be a difficult process, but this prototype also shows that we don't have to keep the same form to make a part that meets the same requirement. Design-for-DIY can require us to change the product itself so that it becomes easier to make.

The shape of the bell also made it difficult to customise this product. The shape is critical to the functioning of a bell, so there is less freedom in form. Other ways to customise need to be found to give these parts a personal touch.

Unfortunately, this change did turn the relatively simple production process of a bell into a method requiring multiple steps, losing the initial metaphor in the process. In the future, user testing can tell us more about the relevance of the metaphor in creating pleasurable processes and to what extent it leads to product attachment.

### 9.4.3 DIY Chain guard

The chain guard was ultimately chosen as the product to further develop. It is a part that often breaks and that has a large influence on the aesthetics of the bicycle. There were also opportunities to improve the original design of the chain guard to encourage maintenance of the chain. This chapter describes how the chain guard was developed to meet the requirements put forward by this project.

#### Choosing a chain guard design

There are many different types of chain guards from completely closed to almost no protection at all. The Design-for-DIY process and the requirements of this project put some limitations on which designs would be possible to make, but which design would be most preferable? Chain guards can be separated in three categories: fully enclosed, chain runner, partially enclosed. City bikes are commonly equipped with fully enclosed chain guards to keep the chain clean so that it requires less maintenance. But companies like Roetz and Swapfiets have opted to have a partially enclosed chain guard in combination with a stainless steel chain instead. This has a couple of advantages: 1 The chain guard doesn't have to be removed to put the chain back on the bike or when the back wheel needs to be removed. 2 The chain doesn't touch the chain guard when it gets older. 3 It is easy to reach the chain for maintenance. The obvious disadvantage is that an exposed chain collects dirt more easily. But from a product care perspective this has its own benefits. Having a chain that is visible can lead to an understanding of the functioning of the bike and an awareness that bicycle components need care because they get visibly dirty.

These reasons make a partially enclosed chain guard the preferred option for this project. It is able to protect the user's clothes and it is also the design that is easiest to make at home given the wide variety of DIY examples (see appendix 3). Furthermore, a closed chain guard is specific to a certain type of bike. To make one that would fit every type of city bike would be very difficult.



Figure 45: Three categories of chain guards: fully enclosed (Kettingscherm Axa Multi Open), chain runner (De slimme kettingbeschermer), partially enclosed (Tokyobikes - Alloy Chain Guard)

## Vacuum forming a chain guard

Starting with the goal of teaching people about how products are made, I wanted to make a fender from the same material as normal bicycle chain guards. In most cases, chain guards are made from plastic, so this was the preferred material. Thermoplastics are easy to work with because they can be moulded into many different shapes. Given that the partially enclosed chain guards are open from the back, they can be made with a one-sided mould. Vacuum forming was one of the highest-ranked production processes for this project and is perfectly suitable for this application. The process works by heating a flat sheet of thermoplastic above its glass transition temperature. The plastic starts to flow and lose its shape. The plastic is then pulled over a mould that is sitting on a vacuum table. The vacuum then removes all the air between the plastic and the mould through small holes. This leaves a product that perfectly follows the shape of the mould. The process doesn't allow for high parts, undercuts (overhang in the mould) and very detailed parts.

I started by designing a chain guard around an existing frame by making a SolidWorks model of this bike. To mount the chain guard to the frame, I wanted to have a universal point that would fit on every bike. Chain guards are typically attached to a bracket that sits in the bottom hub, but to make it easier to install, my bracket is attached to the bottom stay. This does require adjustment in two directions: how far the chain guard sits away from the bike and at what angle. For the first prototype, a 3D printed bracket was designed to fit this bike perfectly. With this model, I could also design the CAD files for the vacuum-form mould for foam milling on a CNC router.

The first prototypes were made using 1 and 2-millimetre-thick polystyrene. I learned the following things from this test:

- The vacuum forming machine required many different buttons to be pressed during operation. This industrial machine was not user-friendly, and laymen will need support in operating it.
- It took more than two minutes to separate the mould from the part. This was a messy and unpleasant process.
- The Vaseline that covered the mould made it messy and unenjoyable to do the following steps.
- There was a big difference in look and feel between the 1 and 2 mm chain guard. The first felt cheap and flimsy, whereas the second felt like a real product.
- The post-processing steps, cutting the part out and drilling holes, were difficult.

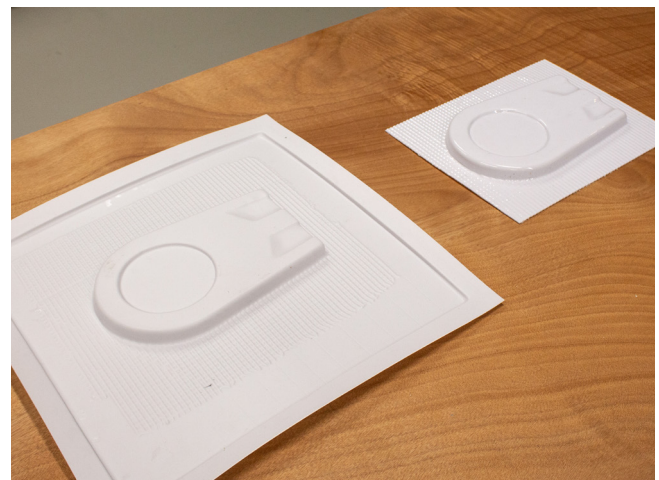
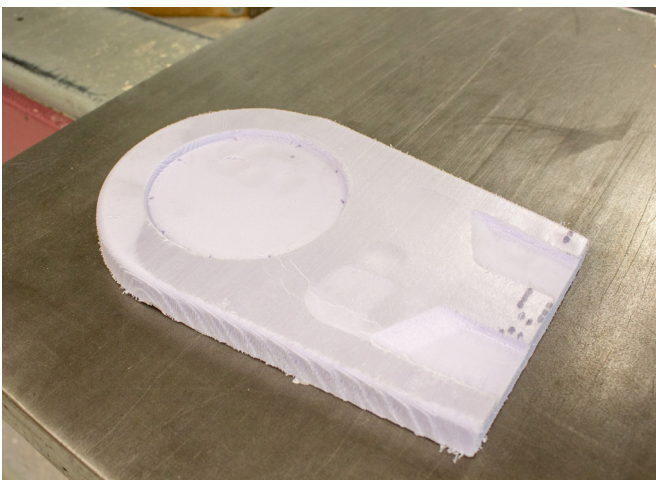


Figure 46: Vacuum forming process using pink foam (left) and

After making the part, it was installed on the reference bike. Because the model was based on this bike, it fit perfectly. The first tests showed that the bracket could hold the chain guard during use and the pants were protected from grease. This design also solves the problem of chain guards being difficult to detach. With two small 3d printed knobs, the parts are easy to remove from the bracket with any key or coin. The design didn't work well with all normal keys, so in the next iteration, the knobs were changed.

This was the first working prototype, and the decision was made to continue to develop this part for future testing and validation. After doing this first test, I learned a lot of ways in which I could improve the part and its production process.



Figure 47: Chain guard prototype installed on a bicycle

### User testing during development

The first step in making the process more pleasurable and enjoyable was to understand the pain points from an outside perspective. Two pilot tests were performed with a week in between to allow for implementing improvements. The first test was for making a fender for a race bike. The idea was that the different frame geometry and gear system would highlight problems in the mounting of the chain guard. A different mould had to be made for this bike.

There were a couple of pain points that surfaced during this user test:

- Making the cutout with a Dremel was scary because the parts could move around
- An extruding pin had to be removed from the crank to install the fender. This pin keeps the chain from getting stuck and is not present on city bikes.
- The participant was happy to have an existing mounting solution, but it didn't allow for enough adjustment in the direction of the bottom bracket. This dimension was especially critical for race bikes because the distance between the crank and the frame is smaller.
- The height difference on the chain guard caused difficulties when turning the fender.
- It was difficult to mark the position of the holes.
- 2mm thick Polystyrene feels: "exactly how I would expect a chain guard to feel"
- The white plastic became visibly dirty during the installation of the part because of a greasy chain.
- Looking for tools caused frustration and made the process feel less streamlined.

After this first pilot, the process was improved. A fixture for drilling and routing the central hole was made, the participant got a set of tools at the start of the process, and the user could customise the colour and mould of the part (see paragraph about customisation). The second pilot test was focused on the pleasure of the process. These were the findings for this test:

- Vacuum forming was the most enjoyable part of the process; everybody in the final test should be able to do this themselves.
- The option to customise made the part feel more like your own.
- Cutting the fender with scissors was difficult, especially the opening for the chain at the end.
- Marking the hole location for the bracket was hard to do by yourself.
- Installing the bracket didn't allow for easy adjustment, and this caused frustration.

### Routing jig

The routing jig utilises a Dremel with a small diameter milling bit. These tools are both affordable and commonly found in maker spaces. Dremel offers an add-on to turn the product into a router, but for this jig, I made a custom 3D printed version. This version is safer because it covers the spinning part of the Dremel and also rotates perfectly around a central point to cut a circle.

To use it, the user needs to drill a hole in the middle of their chain guard. It can then be laid on top of the mould, and the jig is screwed into place. The screw now acts as a pivot point for the router, and the circle can be cut in a matter of seconds. The result looks professional, which is important for the feeling of accomplishment. And because all the parts are fixed in place, even inexperienced users can safely use this tool.



Figure 48: Dremel router jig for cutting a circle



Figure 49: Customisation of chain guard using wooden rings (Photo by Patrick Wetzels)

## Customization

To meet the requirement of customization different ideas were explored for the chain guard. With this production process, there were opportunities for customisation, both in shape and colour. In the initial concept, there would be many different moulds with different shapes to give them personality, but because the available space is limited, it is difficult to make shapes with much depth. This would also create a large number of different moulds that add to the cost of the concept. Instead, I developed a ring that could leave a small embossed feature on the surface of the chain guard. These rings are made by engraving the pattern using a laser cutter, and give the option to quickly customise without replacing the entire mould. The height difference is clearly visible in the product. If the premade rings don't give enough feeling of customization they can be made to the user's design or can be engraved by the user by hand. Following this idea, printing press letters could be made to fit the ring so that people could add their own name or message to the fender.



Other options for adding graphics were considered. Paint is not an option with the requirement that people need to use the part directly after the workshop. The smooth plastic surface needs a primer to give good adhesion, and drying times would not fit in the scope of this project. Instead, permanent and paint markers will be tested because of the quick drying times and durability on smooth surfaces. In addition, stickers can be used to customise the chain guard. Laptops are often customised in this way because they have a large flat surface, but with the current chain guard design, this is also an option.

Figure 50: Selection of polystyrene colours that users can choose from



## Plastic selection

Initially, during prototyping, a plastic type was chosen that was easy to work with. In the faculty workshop, PETG and Polystyrene are the only two plastics that are used for rapid prototyping. The difference with this project is that the parts are made for long-term use. This means that resistance to temperature changes and UV light is critical. The table below compares common vacuum forming plastics based on the relevant characteristics.

The only suitable plastics for DIY vacuum forming are PETG, PS, Acrylic and PVC because of their low softening temperature. Of these options, PETG doesn't come in opaque coloured variants, PS isn't suited because of the low UV resistance and the fumes that escape when heating PVC are toxic and dangerous. This makes acrylic or PMMA the most suitable option for this project. I was not able to test this material on the machine at the faculty because it was difficult to change the vacuum form machine settings.

Plastic Type	Formability	Softening Temperature	Recyclability	UV Resistance	Colour Options
PMMA (Acrylic)	Good	105°C	Type 7 (Other) - Limited	Excellent	Yes
PC (polycarbonaat)	Excellent	155°C	Type 7 (Other) - Limited	Good	Yes
PETG	Excellent	85°C	Type 1 - Widely recyclable	Medium	Only transparent
PS (Polystyreen)	Good	100°C	Type 6 - Limited availability	Poor	Yes
ABS	Excellent	125°C	Type 7 (Other) - Limited	Poor	Yes
PP (Polypropyleen)	Good	135°C	Type 5 - Widely recyclable	Good	Yes
PE (Polyethylene)	Fine	125°C	Type 2 or 4 - Widely recyclable	Good	Limited
HDPE	Fine	140°C	Type 2 - Widely recyclable	Excellent	Limited
PVC	Good	100°C	Type 3 - Challenging	Medium	Yes

Figure 51: Plastics comparison based on relevant requirements

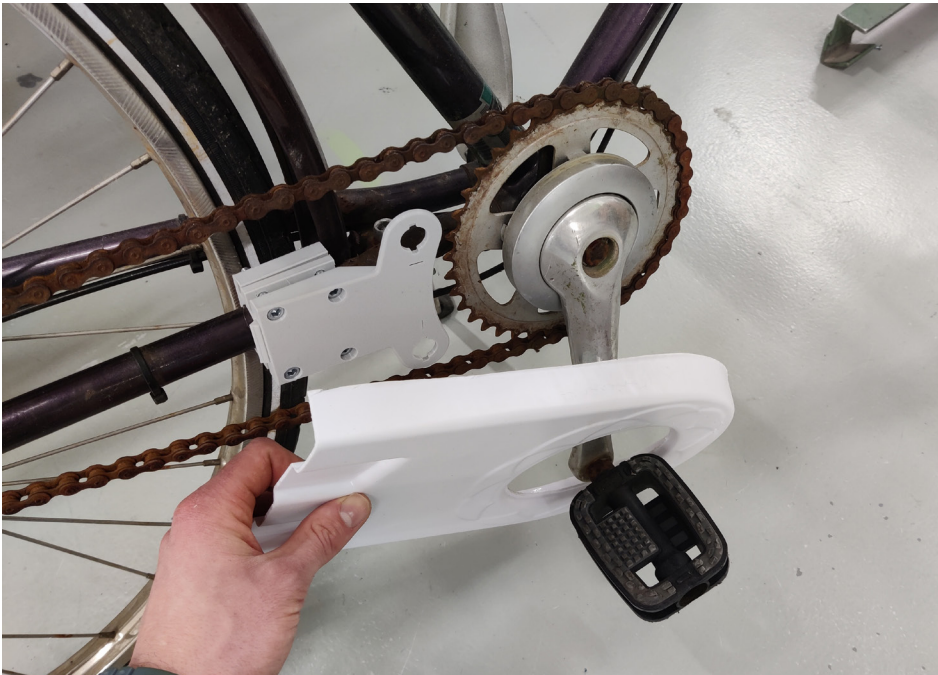


Figure 53: Installation of the chain guard

### 3d printed bracket

The user testing showed that there needed to be more flexibility in the mounting of the plastic bracket. The most important form of adjustment was the distance from the bicycle. This distance is crucial to prevent interference with the crank. The angle also needs a slight adjustment. This was covered by the first design, but this caused the whole bracket to move sometimes. Lastly, the chain guard needs to sit perfectly in the middle of the bottom hub to prevent the sprocket from touching the part.

I came up with several ideas for making this work, but in the end settled on a wedge design. By moving the wedge left to right, the distance from the bike can be adjusted. After making the first iteration, the bracket was mounted to 5 different bikes to check compatibility (see Appendix 4 for the results). For two of these bikes, the bracket sat too far out and interfered with the crank. The new design with the wedge added so much thickness that it didn't work on all bikes anymore. A new design was made that would work with these bikes, but this design didn't have enough space to include the height adjustment. Further steps are needed to improve this design, but given the timeframe of the project, these two designs were used during validation. Following my experience, I think it will be difficult to make a bracket that fits every single city bike, but 90 % should be achievable. For the other cases, a parametric CAD model that can easily be adjusted could prove to be an option for the remaining bikes.



Figure 52: 3D-printed bracket prototypes

## Findings

This paragraph focuses on the practical implications for the design of the chain guard. These show examples of how a product and the making process change when designing for DIY.

- Jigs were used for making holes and marking locations. For example, for the hole in the chain guard. The jig made it easy to get a high finish quality and repeatability.
- Adding reference geometries. A small hole in the vacuum form mould was made to mark the centre location. This reference could then be used to align the circle cutting jig in the next step, making it more convenient.
- Simplify the shape. The back of the chain guard was simplified to make it easier to cut it out at the end.
- Loose tolerance on buttons. These loose tolerances allowed for bigger inaccuracies in the making process.
- It is not the number of steps that is important but rather how easy they are to perform.
- Plastics turned out to be an effective material for the parts. It is easy to form and usually doesn't require an additional finishing step. Recycling does need to be considered, especially for the vacuum forming process, because a lot of waste is created.

The decision was made to use the chain guard as a case study for the entire concept and use it for further user testing.

### 9.4.4 Conclusion

The conclusion answers the three questions that were introduced at the beginning of this chapter.

#### **Is it possible to make DIY universal bicycle parts that meet durability requirements?**

I can say with certainty that the parts that were chosen at the beginning of this chapter are well-suited for the DIY process. This is both supported by the wide variety of DIY examples already available and my own prototypes. DIY parts are not suitable for teaching about traditional production techniques, however. This was exemplified by the bike bell and the fender. Moulding sheet metal required forces not commonly found in a maker space, and therefore, the design had to change completely. Furthermore, it is difficult to make universal parts given that bicycle designs vary greatly, but because parts are made during the workshop, they can be adjusted to fit.

#### **Can the process of making DIY bicycle parts be made pleasurable?**

Concerning the pleasure of the process, making the parts led to the greatest feeling of satisfaction during the pilot tests, but the installation steps need to be optimised. This is best achieved by involving more users in designing the process. Designing for the pleasure of the process is possible and has clear implications for the design of the parts as well as the workshop environment. Parts changed in terms of material selection, and geometries were added to aid the installation process.

#### **Would it be possible to turn this concept into an open-source platform driven by a family of machines?**

The vision of a family of machines doesn't seem feasible. Instead, the open-source platform should provide multiple ways of making the bicycle parts so that workshops can choose the design based on the machines that they have available.

# 10 Testing

To evaluate whether the concept helps to extend the life of city bikes in the Netherlands, user testing was required. This chapter describes the method and results of a DIY chain guard workshop, given to 4 students at the TU Delft.

## 10.1 Focus

Based on the goal of my research, the following questions are formulated. This is the focus of the user testing, which influenced the testing method.

1. Is the process pleasurable and enjoyable?
2. Are users less likely to discard their bikes after the workshop?
3. What are people willing to pay to make this part?
4. Does making bicycle parts improve the user-bicycle relationship?

To answer the first three questions, a questionnaire was developed. This questionnaire includes 16 statements with Likert scale data. An overview of these questions can be found in the appendix 5. Because of the complexity of the last question, an open discussion format was chosen where participants could share their experiences.

## 10.2 Method

### Procedure

At the start of the user testing, the bikes were brought into the workshop. Here, a short introduction was given about the project and the workshop. The participants were asked to imagine the workshop taking place at a local bicycle repair shop to provide context. I also explained that participants were encouraged to help one another. This was made explicit so that the research conditions wouldn't prevent them from interacting with each other.

Participants were then asked to sign a consent form, see Appendix 6, and fill in the first part of the questionnaire with general questions. Then the workshop officially began with vacuum forming the parts. When the two plastic sheets were formed, the first participants began producing their parts, following a digital instruction manual. The other two participants started 10 minutes later. At the end of the workshop, the participants completed the rest of the questionnaire, and we had an open discussion about the process.

### Setup

The workshop was split over two workshop spaces at the faculty of Industrial Design. The majority of the work happened in a large open space that is commonly used for prototyping, while the vacuum forming was done in a different workshop with heavy machinery. The setup consisted of one large workbench where participants could see each other and interact while working. For the step of cutting a hole in the chain guard and customization there were separate workstations. Each participant was given their own yellow toolbox with all the things that they would need to complete the part.



Figure 54: Workshop setup: main workbench (left), separate station (right)

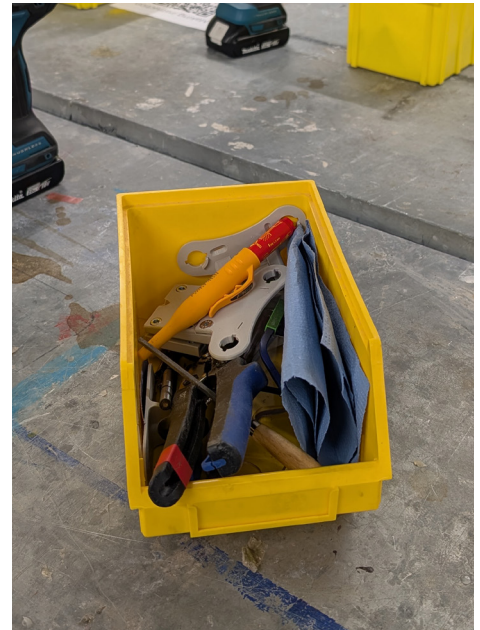


Figure 55: All the tools and supplies are included in the yellow toolboxes

## Guide Instructable

The instructions for the workshop were provided using a digital format. They were hosted online on [www.instructable.com](http://www.instructable.com) and could be accessed using the participants' own phone. The manual used the proven Instructable structure, consisting of a short introduction with the supplies needed, followed by a number of steps. This process was divided into 8 steps: Check if the chain guard will fit, Vacuum forming, Cutting a circle, Cut it out, Attach to the bike, Adjustment, Customize and Be proud.

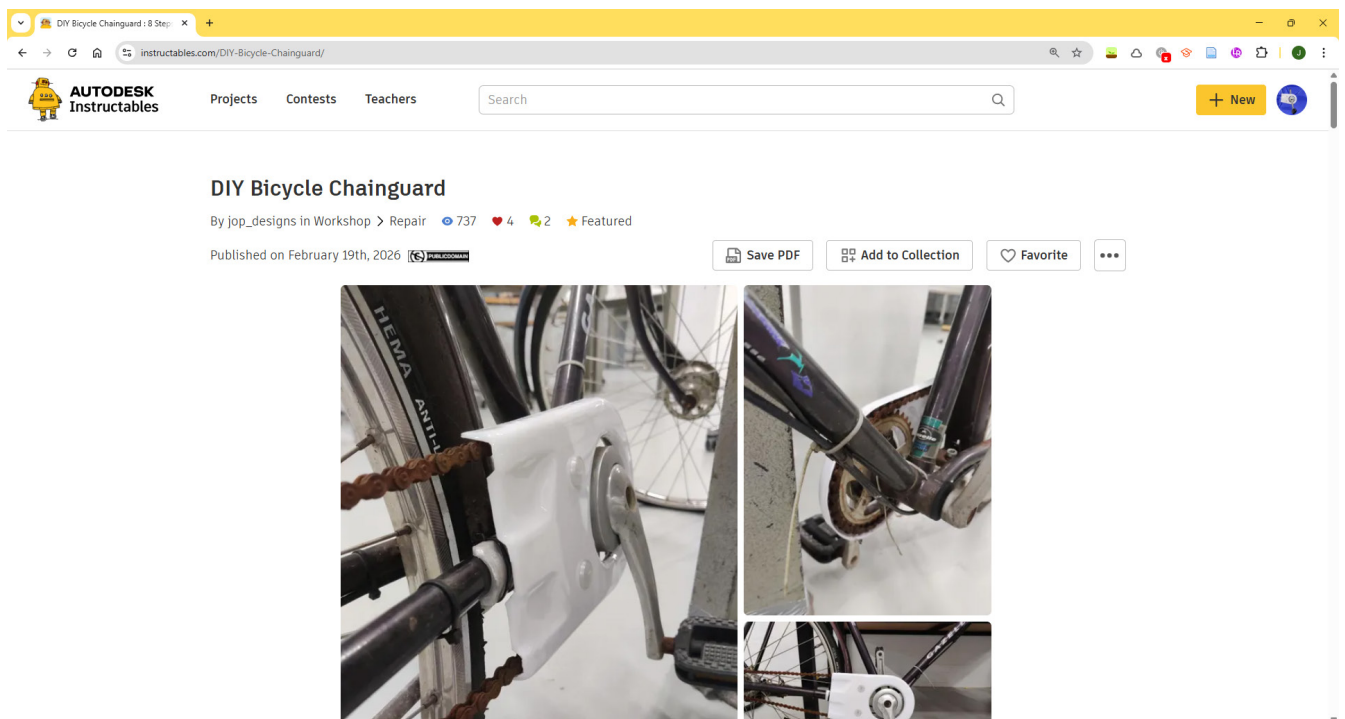


Figure 56: Workshop Instructable (jop.designs, n.d.)

## My role during the test

I took a passive role, only answering questions when necessary. It was important that the participants were given the opportunity to figure out all the steps themselves, because this can lead to a bigger feeling of accomplishment. I also engaged in conversation to lower the barrier to asking questions.

## Participants

To find participants, a workshop announcement was sent among peers and in the maker community chat of our faculty. This announcement mainly attracted people who were already proficient in DIY and cared reasonably about their bike (see table below).

Participants	Gender	Experience with DIY (1 to 7)	Current bicycle attachment (1 to 7)
Pilot	Women	2	5
1	Man	4	3
2	Man	5	6
3	Man	6	6
4	Man	7	6

It was difficult to find people who were interested in joining the workshop. I did receive a lot of messages from people with race bikes who were interested. I believe that this group generally cares more about their bike and also has more experience with DIY. This confirms the barriers mentioned in section 8.2 about the attractiveness of the current concept.

## 10.3 Results

Given the small group of participants, it is not possible to draw any statistically significant conclusions using the questionnaire. However, this data can give a prediction about what the results would be for a larger sample size.

The process was considered highly pleasurable and enjoyable. Pleasure scored an average of 6.4 out of 7, and enjoyment scored an average of 6.6 out of 7. The participants said that the workshop was fun because they got to work with a new machine and see the part form in front of their eyes. They were also willing to recommend the workshop to their friends, scoring a 6,8.

The results also give an indication that the workshop can lead to better bicycle retention. Participants said they would be less likely to replace their bike if it needs repair, scoring a 6,4 out of 7. Related to retention are product care and attachment. Both scored above a 6 on average.

4 out of 5 participants were willing to pay between 10 and 15 euros, with one person willing to pay more. This is exactly what a similar chain guard would cost at the store. This shows that people value their own creations as much as products that are professionally made.

I found that it is difficult for people to talk about product use in terms of a relationship. This made it difficult to draw any conclusions. But, since a close connection exists between attachment, care and product-relationship, this test suggests that the workshop led to an improved user-bicycle relationship.

Finally, there is potential that this concept can increase people's confidence in repair and encourage self-repair in the future. Participants said they would be less scared to repair their bike in the future after the workshop, scoring 6,6 out of 7. Overall, the results were very positive and underline the effectiveness of the concept.

## 10.4 Findings

During the research, I collected insights from observations and talking to participants. These were divided into five categories.

### Process

- The vacuum forming process gave the participants a moment to break the ice before the workshop began.
- Participants didn't want to wait when their part was vacuum formed, but wanted to continue immediately.

### Interactions

- Participants looked at other people to find out how the processes worked and discussed them among each other before asking me.
- The fact that the two groups were at different parts of the process encouraged the participants to help each other. This was a result of the vacuum forming process, but could be done on purpose to increase interaction.

### Tools

- Participants were often unclear on where to find the right tools, even though I had provided them with all the necessary tools in their own toolbox.
- Using a scribe for marking the location of the holes was not self-explanatory.
- The plate scissors required too much force to use comfortably.

### Setup

- After a full workshop, the router station was completely covered in small plastic chips, making the workbench look untidy.
- 4 people were a good number for one workbench.
- Participants didn't enjoy getting into uncomfortable positions on the floor to install the chain guard. This could be prevented by using a hanger or a bike stand.

### Product

- The brackets were difficult to understand. There are too many incorrect ways to install them, which could be prevented by changing the geometry.
- The participants liked the option to choose a colour and a pattern for vacuum forming, but didn't want to draw or add stickers to their part because they could 'ruin' their work.
- Not all participants were satisfied with the result that came with using the plate scissors.

# DELIVER



Photo by Patrick Wetzels

## 11 Final concept: UpKeep bicycle parts

This chapter presents the final concept for this project called UpKeep bicycles. It shows all the parts of the concept and how these will work in synergy to improve the retention of city bikes in the Netherlands. With these materials alone, others should be able to continue where I finished my Master's thesis.

This chapter first explains all the stakeholders and components that together form the product ecosystem. A branding overview is given that will help to create a common design language for all future materials.

The design of a website is presented, which has become the main way to showcase the project and to connect stakeholders. It presents all the relevant progress with materials that are relevant for future development.

The design for a chain guard was finalised during the project and acts as an example for what other parts and their making process might look like.

Guidelines are given as a result of an extensive research through the design process. These will help the community to design parts and workshops that are in line with the philosophy of this project.

The financial viability is explored to give an estimation of the payback time of this concept when employed by different workshops.

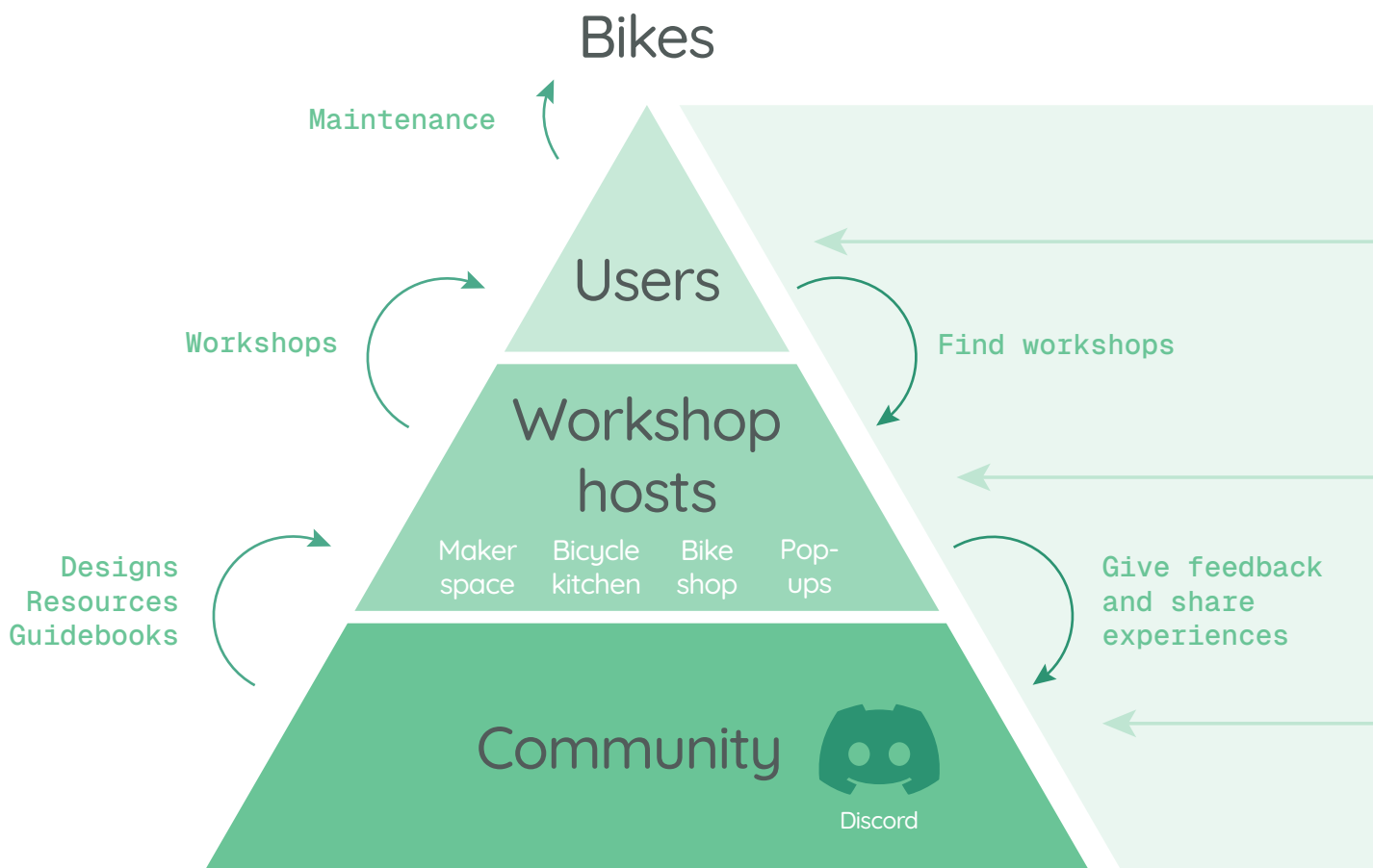
And finally, the sustainability of the concept is discussed. Reflecting on the initial goal and how this concept can contribute.

### 11.1 The ecosystem

UpKeep is an open-source library of eight parts that people can make to extend the life of their bike. The parts can be made at organised workshops across the Netherlands, where they will be guided by experienced makers. The ecosystem is supported by a community that keeps developing new designs, guidebooks and resources. The open-source nature of the project is important to enable other people to collaborate and improve. The resources made during this project give direction to the community and are hosted on the Upkeep Bicycles website.

The image below shows all the important elements of the ecosystem and how they interact with each other. It also makes a distinction between the parts that have been made during this project and which need further development by the community.

# ECOSYSTEM



With this ecosystem UpKeep bicycles hopes to have a considerable impact on extending the lives of bicycles. The impact is determined by the number of hosts that will become part of the network. Based on the number of hosts in the Precious Plastics network it is realistic to have 40 hosts in the network. If these would all host 2 workshop a week around 23,000 bicycle parts could be made each year. Potentially saving all these bikes from being disposed of.

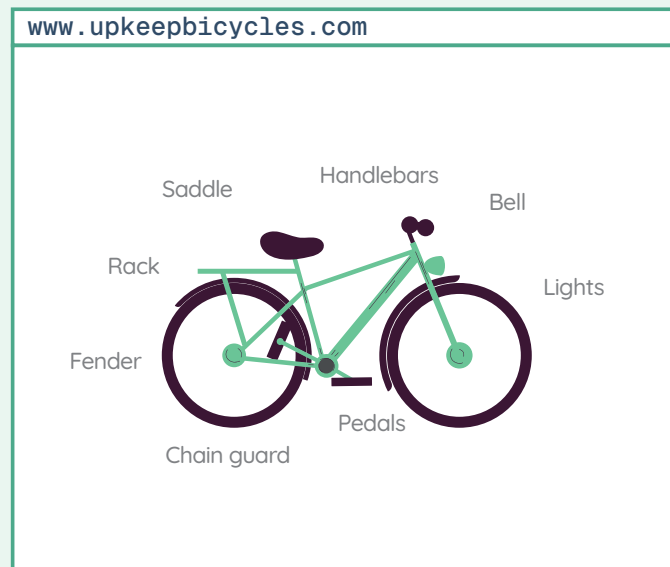
# PROJECT CONTRIBUTION

## Website

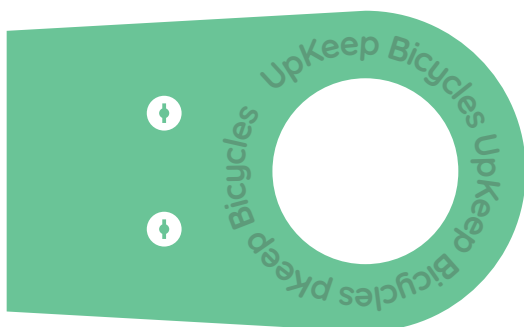
Promotional  
video &  
Instruction  
video

Guidebook

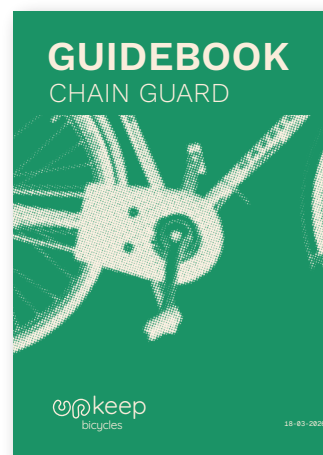
Product &  
Workshop  
Guidelines



## Chain guard design & guidebook



- Chain guard
- Instructions
  - Video



- Setup guide
- Technical drawings
- Material suppliers
- Cost estimation
- Workshop checklist

## 11.2 Branding

Branding will be very important for the success of UpKeep bicycles. Through branding and marketing strategies, people will be able to recognise UpKeep and develop positive emotions towards the brand. This can help to turn bicycle maintenance into something attractive and worth doing. Upkeep literally means to keep something in good condition. It also contains the word keep, which is the goal of this project, for people to keep their bikes for longer. The word Up also gives the brand a positive connotation.

Because the parts show visible changes to the bicycles, they become riding advertisements for the brand. The logo should therefore be a standalone mark that is easy to recognise from a distance. Effective branding can create social value for the project, which is currently lacking for city bikes. UpKeep can become a brand that people want to be a part of.

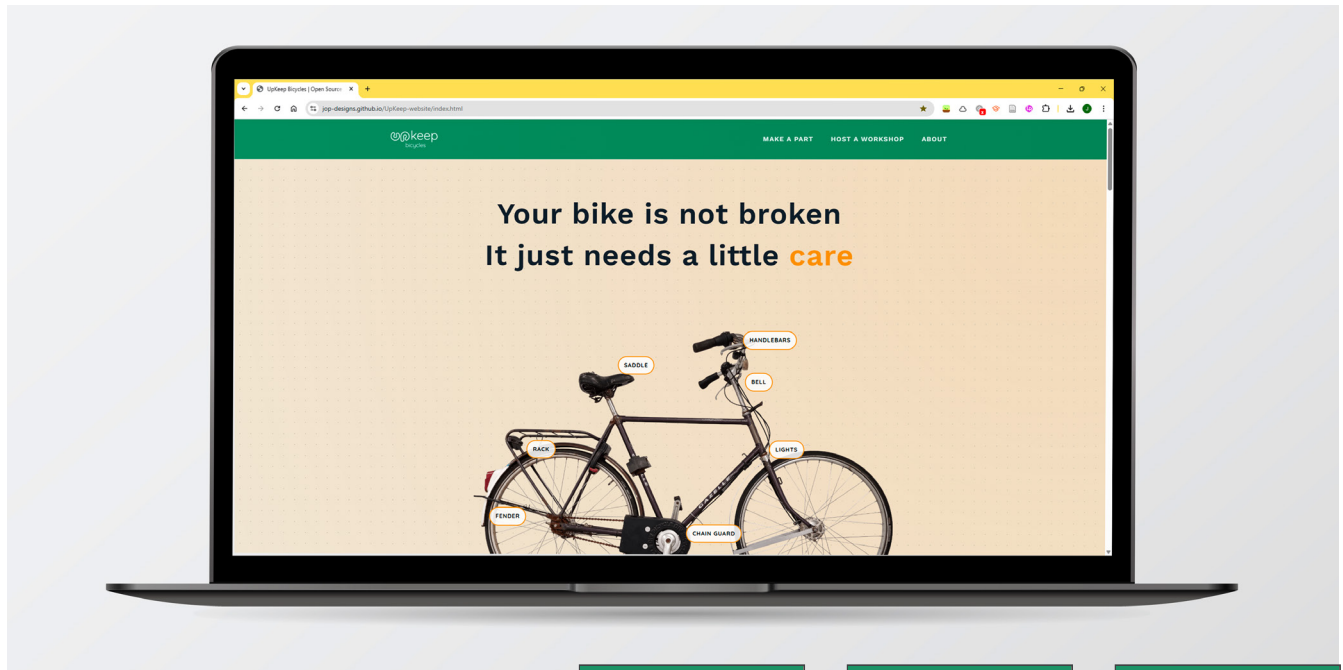


Figure 57: UpKeep bicycle style sheet with logo explanation

I've designed the UpKeep logo to be playful and motivational. The rounded corners and slight rotation of the letters U and P achieve this. UP was designed to be used as an individual trademark and derives its form from different bicycle parts. In terms of colours, green helps to convey the sustainability goal of this project, while orange brings an optimistic and friendly note to the brand.

## 11.3 Website

In order to have an impact, it is important that the project reaches the right audience. After interviewing two people from the maker community (see Appendix 7), I decided that a dedicated website would be the best format. The website provides one central place for all the stakeholders to connect. It also serves to create awareness of the problem and to give reasons why people should take more care of their bikes. Pictures of bicycles with the DIY parts can help to inspire people to take action and use their bikes for longer.



Firstly, the website targets the user, the people who want to make parts for their bike. Through a map, they can easily find a workshop near their home. This map shows all the hosts that are associated with the project. For hosts, the website provides all the needed files and acts as a way for them to connect. Lastly, the website will be used to form a community around the concept. The website will have a call to action for makers to join a Discord community where people can work together on the project.

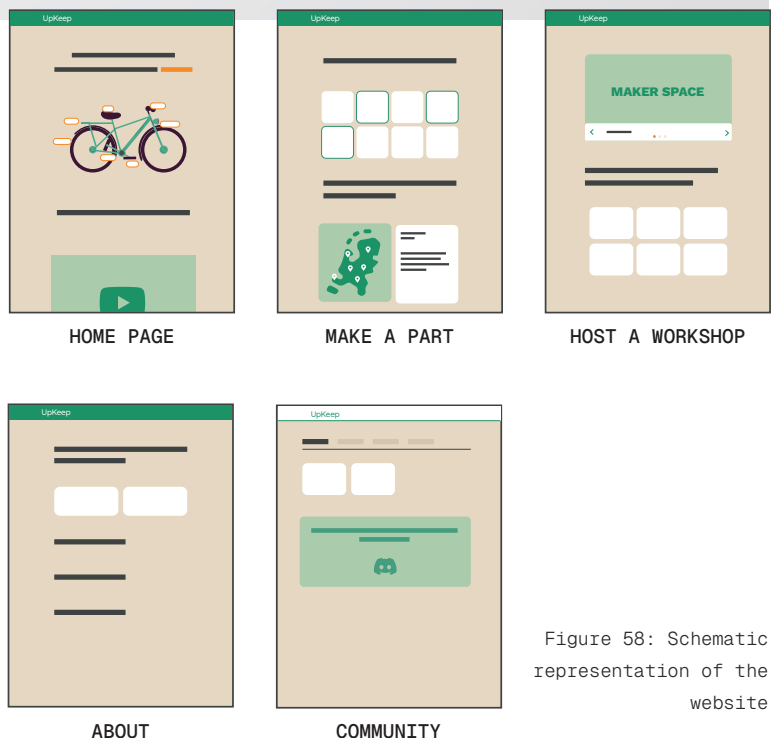


Figure 58: Schematic representation of the website

For more information, visit the website at:  
<https://jop-designs.github.io/UpKeep-website/>



## 11.4 The chain guard

Of the eight parts chosen for the concept, a chain guard was developed to illustrate its embodiment. This part was also used as a case study to understand which elements should be developed for the rest of the parts. In a way, the chain guard was the blueprint for the rest of the project. The partially enclosed chain guard is vacuum-formed out of polystyrene. Using an MDF mould, it can be customised by swapping out wooden laser-engraved inlays. This form of customisation was chosen because research showed that users want to make their part unique without requiring them to be creative.

Figure 60: DIY chain guard installed on a bike

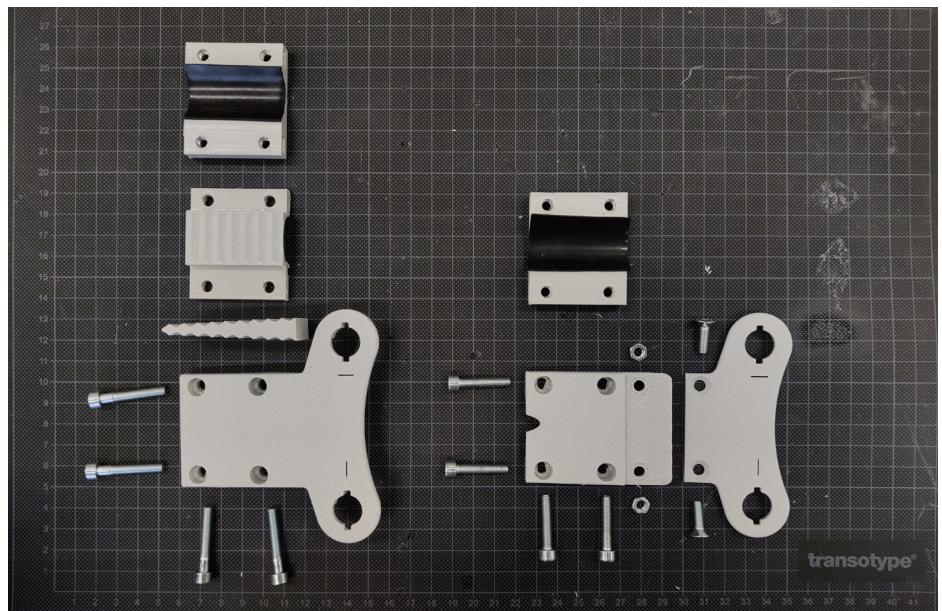


Figure 59: Two different mounting brackets: wedge design (left), slim design (right).

Finally, a guidebook should be available for workshop hosts that helps with setting up the workshop, the space and finding the right tools and materials. Before the workshop itself, a checklist will help to make sure that everything is prepared. This and all the other resources can be found on the project's website.

The most important resource for workshop hosts will be making instructions. A complete instruction with all the steps was made, including a video. The guide was hosted on Autodesk's Instructables: <https://www.instructables.com/DIY-Bicycle-Chain-guard/>



Figure 61: Customization with mould inlays

## 11.5 Guidelines

This paragraph combines the findings from the design process (chapter 9.3.4, 9.6 and 10.4) to give guidelines that can act as a starting point for the community to develop new parts and workshops.

### Product

1. **Embrace the handmade aesthetic.** DIY parts don't need to look or function exactly like the original.
2. **Guarantee success on the first step.** This step should make participants feel satisfied, which carries on through the rest of the workshop.
3. **Design for available and accessible tools.** Use easy hand tools or machines that are not specialised.
4. **Design for loose tolerances.** Make sure that the part still works when you're not so precise.
5. **Price the DIY version comparably to the store-bought alternative.** People are willing to pay for the experience and craft.
6. **Make every step straightforward.** Design jigs or modify the part geometry so that difficult or tedious steps become simple and repeatable.
7. **Make customisation easy and guided.** People should be able to personalise their part without needing to make creative decisions.

### Workshop

1. **The feeling of accomplishment is part of the value.** Let participants figure things out for themselves before stepping in.
2. **Always bring the bike to the workbench.** Using a stand or hanger can make bike maintenance more enjoyable.
3. **Give every tool a place.** Provide tools in separate toolboxes with dedicated spots for every tool.
4. **Divide the process into separate stations,** each dedicated to one step, arranged to create flow
5. **Work in small groups of 4–6 people** per table to encourage collaboration without overcrowding.
6. **Keep the total workshop time under one hour.**

## 11.6 Financial viability

UpKeep bicycles will be built on a network of shops and maker spaces, but what does it take for these shops to pay back for their investment?

Investment costs were estimated, consisting of all the tools and supplies needed for running the workshop. The chain guard workshop was used as an example for the calculations. The material cost per chain guard was calculated, and the cost price was set at 15 euros based on findings from chapter 10. Wages were determined based on the minimum income salary for somebody working for two hours.

Cost	Amount in euros
Investment	€820
Material cost per chainguard	€8.14
Wages per workshop (only for bike shop)	€30
Income per chain guard	€15

Figure 63: Estimation of cost and income for chain guard workshop

These numbers made it possible to calculate the break-even points for the different types of hosts. The hosts differ in terms of their investment cost and cost for wages (see Appendix 8). The numbers show that bike shops will need the longest time to pay back for the system. This is mostly because they don't work voluntarily. To create a sustainable business model for bike shops, they can raise the selling price, with the risk of competing with other hosts in the network. Maker spaces and bicycle kitchens are ideal for hosting workshops. Because of the support from their maker community and the already available tools, they have lower investment costs. Lastly, a pop-up van is proposed as a way to spread the concept. This van would need to drive around and be responsible for hosting at least 65 workshops before a break-even point is reached. This makes pop-ups only possible with funding or grants.

Type of workshop	Number of workshops	Number of chain guards
Bike shop	73	440
Bicycle kitchen	20	119
Maker space	14	85
Pop-up van	65	391

Figure 62: Break-even point based on number of workshops and number of chain guards

The calculations show financial viability for Maker spaces and Bicycle kitchens, but also highlight the small margins when it comes to Bike shops. A template for estimating the cost should be added to the website as a way for hosts to inform their financial decision to join the network.

## 11.7 Sustainability

The goal to extend the lives of bicycles in the Netherlands originated in a sustainability frame. When the project progressed, it became clear that this would only happen if people started to change their behaviour. The project focuses on this behavioural change, but we should not overlook the carbon footprint of the solution itself.

By making a product in a DIY fashion, there are fewer opportunities for optimisation of materials. When a chain guard is injection moulded on a production line, it requires only a small amount of excess material. For vacuum forming, this is not the case. There is a lot of waste material created when the part is freed from the vacuum forming sheet. However, since it is a non-polluted waste stream, the plastic can easily be recycled if the right material is selected (see Chapter 9.4.3).

This shows a solution for the production waste, but is there also a way to make a chain guard from recycled materials? The timetables from the Dutch railway company NS were used as an example. Originally, the timetables were made from a thick plastic sheet. The modern ones are thinner, and fortunately needed to be reinforced with virgin plastic. The result is a chain guard that is even more unique and has been made from a waste stream. The NS has been making an effort to turn all of its waste into products, which are sold at larger stations, and this design can be directly added to their product portfolio. This shows the potential to use recycled materials for this concept, making it even more sustainable.



Figure 64: NS timetable signs at Rotterdam Central Station



Figure 65: Vacuum forming prototype of NS chain guard

## 12 Discussion

### 12.1 Difficulties with adoption

The project shows promising results when it comes to increasing city bike retention, but it has not fully addressed the problem of adoption. The concept relies on two motivators, perceived pleasure and interest, which are likely to be more effective with people who are already familiar with DIY.

For people who don't see themselves as 'makers', this project can actually pose new barriers to entry compared to normal bicycle repair and maintenance. To have a significant impact on bicycle retention, however, the project should also address this target audience.

By focusing on *Design-for-DIY*, the target audience was determined at the beginning of the project. By taking pleasure in the process as a starting point, I have tried to make it as attractive as possible for non-makers, but this doesn't mean that it will be adopted. I think that this is part of a bigger societal problem that falls outside the scope of this project.

### 12.2 Changing the future of product care with bicycles

This master's thesis focuses on a wicked problem. A problem that I believe is far bigger than the neglect of bicycles alone. The broken human-product relationship is part of our Western culture. Of how we look at products and how we value them. Besides working on finding a solution for our unsustainable product relationship with bikes, I believe that the project has a purpose in creating awareness around this issue.

Consumers already care about a lot of their products, but usually not mass-produced products, like household appliances and bicycles. These are the products that have the most influence on the environment and should therefore deserve the attention of designers. The popularity of the circular economy within the field of design shows a move to a more sustainable future. But most of these strategies focus on how to deal with products after the use phase. This project showed me that, for low-cost products, the challenge for designers will be to create emotional value, which will lead to product care.

Caring about products currently doesn't give social status. Instead, we talk about our products in terms of how much money we paid for them. If this were to change to a status driven by the emotional value of products, repair and maintenance would become much more attractive.

The maker movement is already changing the narrative of our consumerist mindset and showing that repairing, making, and mending are activities that show care towards the objects we own. Bicycles are interesting objects to use for the purpose of creating awareness because they are so common, visible, and relatively easy to work on. I think that an open-source community focused on bicycle maintenance has the potential to change our relationship with products in general, not only bikes. To change the cultural narrative from talking about the value of products when we buy them to talking about adding value during use.

### 12.3 The value of owning our products

It could be argued that a more sustainable future is one where we don't own products at all. In the cycling industry, Swapfiets is a great example of this. When the company keeps ownership over the product, it will benefit from taking care of it and extending the life of the product. But what this doesn't allow is for people to create an emotional connection with the product. When renting a Swapfiets, we see the bike even more as a functional object with only a functional value.

These business models seem like the only way to consume sustainably within a capitalist society. But I believe that they don't allow us to create emotional connections with the products we own if we don't have the responsibility to take care of them.

# 13 Conclusion

## RESEARCH

This project tried to answer the following research question: How can Design-for-DIY support product retention and extend the lifespan of city bikes in the Netherlands? This chapter answers the sub-questions of the research and finally gives an answer to the main research question in the form of a design concept.

### **1. How sustainable is the use of bicycles in the Netherlands?**

Every year, approximately 350,000 bikes are neglected and picked up by municipality services and in total, 800,000 bikes are discarded yearly. The research pointed to the lack of emotional attachment as the main reason for this unsustainable user-bicycle relationship.

### **2. How can retention be supported by Design-for-DIY?**

Within the field of DIY, making, maintenance and repair were identified and defined as three different activities by the research. When a bike needs repair, the owner is forced to make a decision either to repair or replace. If the owner is not already attached to the product at that moment, the bike will be discarded because of its low value to the user. Maintenance and making, however, have the potential to increase user product relationship, before repair is needed, if these activities are pleasurable.

### **3. What are the barriers and motivators that influence the maintenance process?**

Bicycle maintenance is often unpleasant because rust and dirt make it difficult and unpredictable. Getting stuck is an inevitable part of the process, and the user is only rewarded at the end. It was found that an initial experience of success and collaborative environments like bicycle kitchens and makerspaces play an important role in motivating users to finish and enjoy DIY projects.

### **4. How does engaging in making and maintenance change the human-bicycle relationship?**

According to the IKEA effect, labour leads to love. This counts for both maintenance and making, but making adds another level of meaning. Making allows to alter the aesthetic of the product through customisation, it is more creative, and the user becomes part of the history of the product. At the highest level, the product becomes an extension of the self.

### **5. What design opportunities emerge to support DIY engagement and product retention for city bikes?**

The chosen direction focuses on maintenance through the making of DIY parts. This approach combines the benefits of making and maintenance to increase both the functional and emotional value of city bikes that can encourage repair and postpone replacement. Making offers provides more opportunities for the designer to create a pleasurable experience. The process can be designed to fit the level of the maker. Additionally, the feeling of success is moved to the beginning of the process, removing the uncertainty found at the start of a repair.

## DELIVER

### **The UpKeep Bicycles concept**

The resulting design concept, UpKeep Bicycles, provides an open-source ecosystem where users have the option to manufacture 8 different parts during guided workshops. A chain guard, bell, fender, handlebars, pedals, rack, saddle, and lights were chosen because they inevitably break during regular use, don't need to be replaced immediately after failure, and have the greatest impact on the bike's feeling of degradation.

Because not many parties or companies can directly benefit from bicycle retention, the concept was built on an open-source framework to ensure it can be supported by a community of makers. A website was created to connect all the stakeholders and to create awareness around the topic of bicycle care. This project provides guidelines for future development and an example workshop that is included on the website.

Through a research-by-design process and user testing, it was demonstrated that creating DIY replacement parts is not only feasible but also highly enjoyable for users. Participants who engaged in the test workshop reported feeling more attached to their bikes and indicated they would be significantly less likely to replace their bicycles when future repairs are needed. The feeling of success was also found to increase the trust in people's own ability, which can lead to self-repair in the future.

Ultimately, a cultural shift towards product care is needed. By reframing maintenance as a celebrated, creative, and community-driven activity, this project makes a first step towards extending the lifespan of the everyday city bike and inspiring a more meaningful relationship with the products we own.

## 14 Recommendations

This chapter outlines concrete steps to grow the UpKeep Bicycle concept.

Because this project is open-source, it is reliant on an active community to function and grow. At the beginning, attention should go to promotion at maker-focused gatherings, like maker fairs to grow the community. A small group should take the lead in managing the community and taking responsibility for the steps described in this chapter.

Before the concept has been popularized external motivators should be used to attract users. Originally, this project was built on the premise that perceived interest and pleasure in the DIY process would lead to adoption. But because this is not yet widely embedded in our society, the project should rely on external motivation instead. Initially, the project can attract users by lowering the price or by providing bicycle repair services alongside the workshops. In addition, by hosting pop-ups in busy locations, the friction to join can be lowered, and the concept can be popularised.

Another way to expand awareness is through marketing campaigns. Funding for these campaigns can come from partners like municipalities or the Dutch Railways. They can benefit directly from fewer neglected and abandoned bikes by putting less strain on removal services and by helping to clean up streetscapes. These partners should be prioritised from the start. Additionally, by working together with library makerspaces, of which there are over 80 in the Netherlands (van den Dool et al., 2021), there is a potential to roll out the concept nationally.

Eventually, these steps can lead to the popularisation of UpKeep Bicycles. If enough bikes, fitted with these parts, are driving around on the streets, they will become recognised by more people and the project will start to act as its own form of advertising.

## 15 Reflection

I'm very grateful that I was able to choose a topic that is so close to my heart. This made me very passionate to work on it, but I also found that it made it more difficult to write about. Especially during the research phase, I was trying to put the care that I feel for my bike and for other products into words, which seemed almost impossible. I had long discussions with my friends, family and supervisors to understand and structure my thoughts.

One time, I tried to organise my thoughts together with my dad by drawing on a removable whiteboard foil that you can stick on walls. The white semi-translucent foil works perfect on windows, but when the discussion with my dad went deep into the night we started running out of space. In an attempt to continue the discussion we turned the foil around and started writing on the backside. The next morning, when the sun was shining on the foil from the other side, the scribbles showed a jumbled mess of lines. This mess was exactly how my head felt at that time, but through iteration I was able to slowly structure my thought. Iteration has been a theme throughout my entire time studying Industrial design. I have always been scared to show my unfinished work. I believe that every part of this project has brought me one step closer to appreciating the iterative process which is the beauty of design.

Lastly, I'm very grateful that I got to dip my toe in the field of Design-for-DIY during this project. Because it is a relatively new field, I feel like there is no clear definition of it yet. What it means to me is to involve people in the making of their products and to design this process with them. I mainly focused on the pleasure of the process. Funnily enough, I often struggled to embrace the process and the setbacks of this project myself. I write about how setbacks are an inevitable part of repairing stuff, and that I see them as a challenge. But through writing, I was able to put myself in the shoes of people with low self-efficacy when it comes to repairing and making. I now realise that the pleasure of the process mainly comes from a mindset where we are allowed to fail and to see everything as we make it as a process.

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# Appendix

## 1 Improvements for current bicycles

### Hard to reach parts

Due to the design for manufacturing, a city bike is already made for disassembly. The parts are also relatively exposed making them easy to reach and common fasteners are used throughout the bike with a few exceptions. These will be the first point of interest.

In order to remove the bottom bracket assembly, first the cranks need to be removed. This is done using a crank puller. This tool is universal for three types of cranks covering around 90 percent of all cranks used in city bikes. During this disassembly the crank wouldn't come off and WD40 was needed to lubricate the connection. The next step is untightening the bracket hub. Here you are required to have a special tool that sits on the inside of the bracket casing. In all the parts in this assembly it is hard to know whether parts need to be turned clockwise or counter clockwise. Being unaware of this fact makes disassembly very difficult.



Figure 67: Special bike tools: Crank extractor (left), Bottom bracket wrench (right)

A metal working vise was used to do all the work holding. This is not a necessity, but it made disassembly a lot more ergonomic.

Furthermore there were a some parts that couldn't be removed without permanent modifications to the bike. These were the front sprocket assembly and the brake levers. The front sprocket could only be removed by grinding away the material, because the two parts were mechanically fastened by means of forging.

The brake levers are attached to the lever body with a pin that could only be drilled out. This is possibly done because of safety reasons.



Figure 66: The crankset: front sprocket (black) and crank (middle) forged together

### Wear

Rust can be found everywhere on the bike. The most common place is the chain and sprocket. These are high wear components that need to be replaced, especially when the bike is sometimes exposed to rain. There was also rust on the inside of the fenders and in most parts that were connected to the brake cable. The brake cable itself also didn't function anymore.

## Ideas for improvement

Something that is common for anyone who has ever repaired a bike is to have some spare washers and nuts when you are finished putting it back together. Parts tend to be interchangeable but not the same. Common bolt types are used but with different lengths. And the purpose of all the washers are hard to understand for someone without technical insight. This could be improved through colour marking or integrating the function of some of the parts like washers.

Then there are many places where rust forms easily, for example the fenders. If the bolts would be placed on the outside of the fender they wouldn't seize because of the rust. Another reason to make this change is that these bolts are hard to reach when the wheels are installed which making disassembly difficult.

The saddle was also in very bad condition. The (fake) seat leather was cracked and this meant that water and dirt could get in the foam. This did not however change the shape of the foam and with a new cover it could feel like a brand new saddle. A redesign of the saddle could make this possible.

Then there is the gear hub. A very complex assembly with over 50 parts. The fact that all the parts are encapsulated in the hub makes them better protected from the environment, but also really hard to understand. This adds to the perspective that this part is a black box that cannot be messed with. This is often the case with professional repair because of the complexity and this means that when the gear hub breaks the whole wheel needs to be replaced. For reasons of repair and DIY the gear system should be more visible and not connected to other parts so that individual parts could be replaced.

## 2 Personal correspondence, Dr Ackermann

On 7-12-2025 I had the following correspondence with Dr Ackermann. Her research was so important for my master's thesis that I wanted to clarify some things with the person who was responsible for the re-search.

Dear Dr. Ackermann,

Thank you for your quick response on LinkedIn. As I said, I'm working on my master thesis where I'm trying to encourage people to repair or maintain their own bicycles. I believe that by taking care of our own bike, we can improve the relationship with our products.

When I found your work, I was immediately inspired, but I have a couple of questions that I would like to ask.

1. In your paper "Consumers' perspective on product care", you make the point that the ability and motivation of many consumers is already there and that designers should therefore focus on the triggers. For bikes, I feel like the trigger is already there (the bike starts making noises and has more resistance), but people don't have the tools or don't feel motivated to repair. How did you come to this conclusion, and do you still feel the same way?
2. In your latest paper, "No Fun, but Very Effective...", participants seem to be less interested in appropriating their products. Customisation is something that they were more inclined to do as kids. I also feel like adding customisation and creativity can make the care process more daunting. Instead, one of my directions is that people 'make' the parts needed for repair with simple machines. Therefore, they invest time and energy (similar to the IKEA effect), but are not required to customise the parts. What are your thoughts on this direction, given your knowledge on the topic of repair?
3. The following [paper](#) by Terzioglu describes a model for repair motivators and barriers. What is the difference between barriers and ability factors, according to you, and are these directly related?
4. I also found that the triggers from your paper could be reformulated to turn them into motivators. In this way, they give new possibilities for care activities. Do you see any consequences for doing this? Social trigger could be related to the design strategy of 'social connections and challenge based approach to 'anticipating effects' from your other paper, but previous care activity experience and appearance could lead to a new strategy

Trigger	<b>Appearance trigger</b>	<b>Time trigger</b>	<b>Social trigger</b>	<b>Previous care activity experience</b>	<b>Challenge based approach</b>
Motivator	<b>Appearance</b> The repair makes the product more beautiful than it was before	X	<b>Social</b> Do it together with someone else	<b>Previous care activity experience</b> Let users start with a small success	<b>Challenge based-approach</b> Gamify/find personal boundaries

5. Are there any papers that have come to your attention within this field that would be interesting for me to know about?

I want to thank you for taking the time to look at these questions, and I hope you find them interesting.

Hi Jop,

Sorry for the late reply. I haven't been working full-time in research for almost two years now, so I had to think about your questions for a while. I definitely found them interesting.

1. I think I wrote this in one of my publications, but I'm not sure: I believe that the transition between motivation/ability on the one hand and triggers (which increase motivation/ability at a certain point in time) on the other is fluid. I think it's a question of timing: you get used to some things, such as a bicycle that makes noise when riding, in everyday life after a period of ignoring them; the noise can then no longer function as a trigger that increases motivation for a very limited time. In such cases, a new trigger (e.g., a friend who is also repairing their bicycle?) would be necessary. I think my classification based on the interviews was often made in the immediate context of the

statement and is certainly also a question of interpretation to a certain extent.

2. Making parts for repairs seems like a good approach to me. I also think that individual customization does not generally preclude this, as making these parts probably still offers or can offer a certain degree of design freedom. Whether individual customization is generally a suitable approach depends, in my opinion, very much on the individual and their personality. Therefore, I would find it advantageous if there were an option for customization while making the parts, but if it were not mandatory. One thought that came to mind when I read your description: Couldn't the production of the parts themselves fail again due to (perceived) ability or create (another) hurdle at this point?

3. In my opinion, it is more a question of perspective: Fogg describes ability factors because he wants to define which elements are necessary to bring about behavioral change. Barriers, on the other hand, explain why behavior does not occur.

4. I don't see any reason to disagree with these considerations. As mentioned in point 1, I see the transition as rather fluid and believe that the question of whether an intervention or design feature should be classified as a motivation or a trigger can also change depending on the individual context of the person or situation.

5. As I said, I am no longer actively working in this field, so I can't give you any good tips here. Sorry!

All the best for your continued work on your master's thesis. Feel free to send me a link to the result :)

Best regards

Laura

### 3 DIY bicycle parts

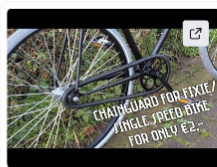
#### Chain guard



Drew&#39;s bike blog

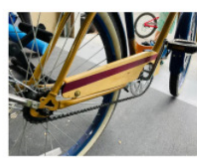
##### Making a chainguard

I had promised my wife a chainguard for her city bike way back when I was building it. Finally after a couple of years waiting, I put one together...



YouTube

##### Awesome 2€ DIY bike chainguard

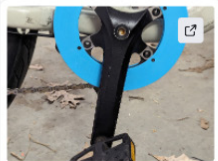


[https://www.reddit.com/r/BeginnerWoodWorking/comments/q412mji/made\\_a\\_bike\\_chain\\_guard/](https://www.reddit.com/r/BeginnerWoodWorking/comments/q412mji/made_a_bike_chain_guard/)



YouTube

##### Adventurers Club DIY Bicycle CHAIN GUARD



Maker Forums

##### Designing and fabricating a new chain guard fo...

One of my kids has a Specialized bike, and the front sprocket came with a plastic chain guard with two pieces surrounding the front sprocket to k...



Printables.com

##### Bike Chain guard (custom) by JoshShabtai...

A custom chain guard for my bike. No idea if it will fit anybody else, but you're welcome to try. The FreeCAD file is also included so you can try to adapt it...

#### Bell



Thesietich

##### I Made A Bicycle Bell

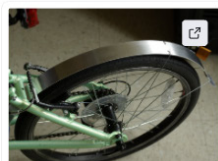
We all know bicycles are one of the best ways to get around, I for one can't go a day without getting on one. Today I woke up and thought to myself, self...



YouTube

##### DIY Bicycle Bell + More Upgrades | ...

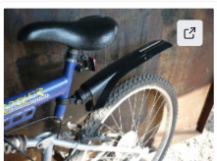
#### Fender



Instructables

##### DIY Bike Fenders

DIY Bike Fenders: For the most part, I enjoy fiddling with bikes more than riding them. I'm really a big baby and I hate riding up hills. That being said...



Instructables

##### DIY 0\$ Bike Fender

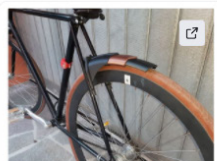
DIY 0\$ Bike Fender: Hello! It's my 1st instructable. Every part and tool for this instructable I've found at home. That's why it cost 0\$.



Printables.com

##### Ass Saver - Bicycle Mudguard by fgebhar...

Perfect application for owning a 3d printer. Saw other cyclists having this hot mudguard on the back of their saddle. Looked it up and it costs ab...



T

##### Bicycle telescopic mudguard with magn...


Piccolo parafrango telescopico con calamiteServono 9 calamite Ø10x2. Vanno inserite durante la stampaSe mi vuoi offrire un caffè questo è...



Instructables

##### Bike Fenders From Water Bottles and Clot...


Bike Fenders From Water Bottles and Clothes Hangers: This instructable will show you how to make fenders for your bike using plastic water bottles, clo...



**T**

**Custom MTB Fender / Mudguard...**

This is the one I've been hanging out for. The Mudguard, the Fender, the most important addition to the modern MTB. Join me on this mountain bike chall...



**T**

**Modular Racing Bike Mudguard by mitrasmit**

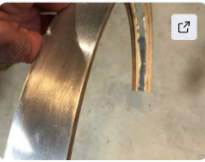
Racing bikes are one of the best modes of transport. But wet roads can be annoying; you'll get a fountain of water spraying upwards from the tyres...



**B** Bicyclists : Omschool Cycling

**Turn two plastic bottles and a hanger into...**

UPDATE No2: Put some pieces of wire to support the construction (check out the blue one in the pic below) UPDATE No3: After almost a year six mont...



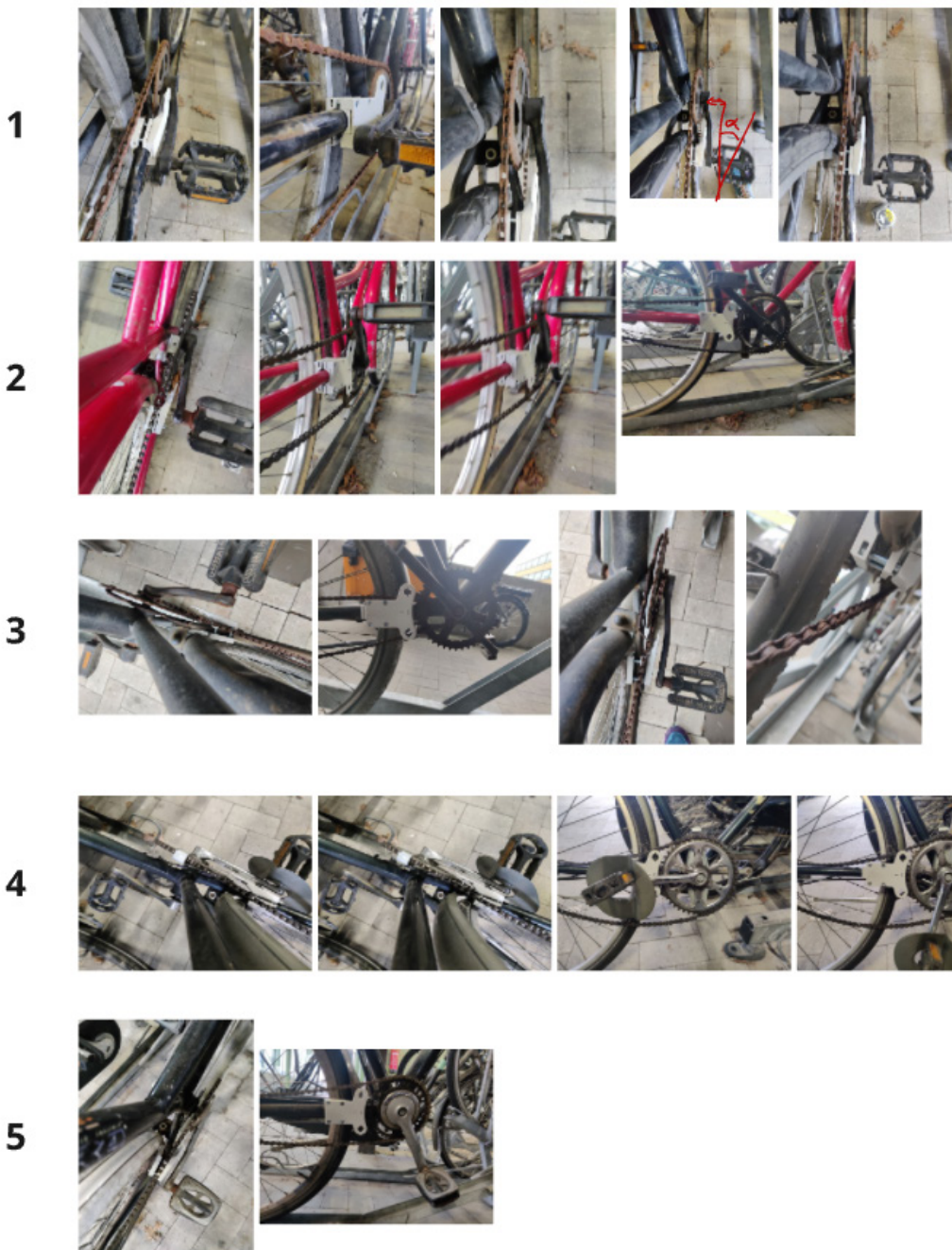
**W** Drew6#39;s bike blog

**How I made my bicycle fenders**

This post is about how I made fenders for my bike. This approach will accommodate any tire size, width, and length; no need for sheet me...

## 4 Testing 3D printed bicycle brackets

These pictures show 5 city bikes with different frame geometries. They were used to test the 3D printed brackets and find any problems. The Adjustable bracket didn't fit on numbers 1 and 2, and this led to the development of the Slim bracket. The new bracket was later tested on these bikes to improve the design.



## 5 User testing results

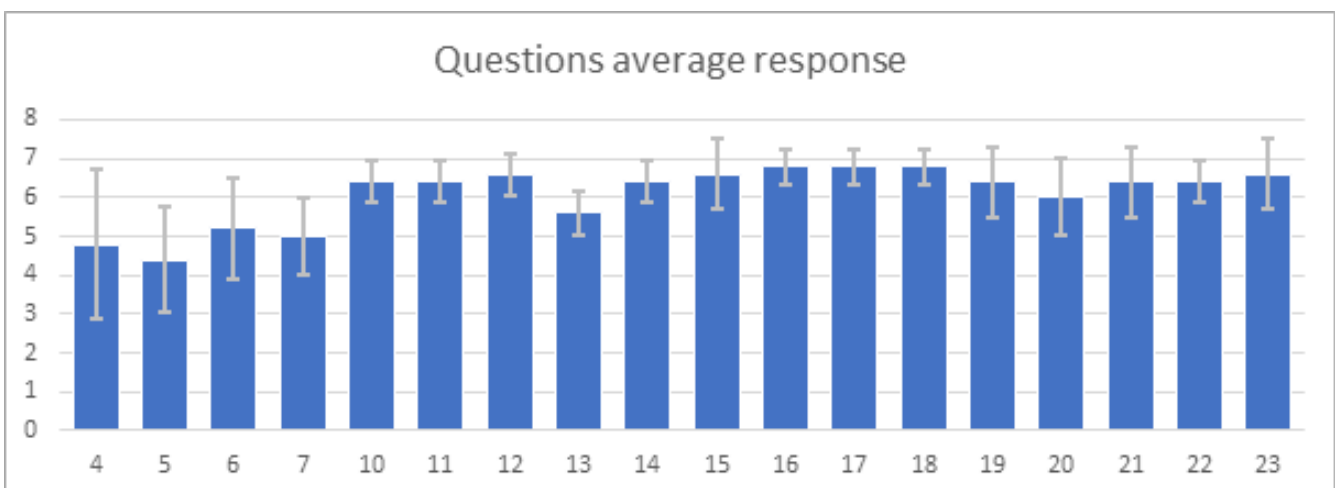
### Part 1

1. What is your age?
2. Which of the following best represents your gender identity?
3. Have you ever repaired something on a bike before?
4. I'm experienced with DIY (Do-It-Yourself).
5. I trust my ability to repair bikes.
6. I care about my bike.
7. I'm sometimes annoyed with my bike.
8. If yes, what are these annoyances?
9. How long have you been cycling without a chain guard?

### Part 2

1. The process of making a chain guard was pleasurable.
2. The manufacturing techniques were interesting.
3. I enjoyed making the part.
4. The instructions were clear.
5. I felt safe using the tools.
6. The steps were easy to perform.
7. There was enough guidance during the process.
8. I would recommend this workshop to a friend.
9. I had a feeling of success at the end of the workshop.
10. The end result looks better than I had expected.
11. I care more about my bike after doing this workshop
12. I feel more attached to my bike.
13. I would be less likely to replace this bike if it needs repair.
14. I'm less scared of doing other repairs on my bike after this workshop.
15. How long would you be willing to spend on making the chain guard?
16. How much would you be willing to spend on this part and the workshop?

### Results



## 6 Consent form

You are being invited to participate in a research study titled Repairing the User-Bicycle Relationship Through DIY. This study is being conducted by Jop Alofs as part of a Master's thesis in Industrial Design Engineering at TU Delft. There are no external collaborating partners or funding bodies involved.

The purpose of this study is to investigate what effect making a DIY chain guard has on how attached participants feel to their bicycle and how much they value it. Your participation will take approximately 90 minutes and will consist of four parts: a short introductory questionnaire, a hands-on workshop in which you will make a chain guard for your own bicycle, additional survey questions, and a brief open group discussion.

During the workshop you will use basic workshop equipment, including a hand drill, a Dremel rotary tool, and plate scissors, to finish a plastic chain guard that has been vacuum formed in advance by a professional. You will be able to observe this vacuum forming process. At the end of the session, the completed chain guard will be fitted to your bicycle for you to keep. Participation in this research is entirely free of charge.

Your survey responses will be collected anonymously and used solely for research purposes. Results will be reported in aggregate and published as part of a Master's thesis, which will be made publicly available through the TU Delft repository. Your personal details will be stored separately from your survey responses, will not be linked to your answers, and will be deleted once they are no longer needed. Only the researcher will have access to this data.

Photos and video footage may also be taken during the workshop. This material may be used on a publicly accessible website and in a video published on YouTube. Your explicit consent for this will be requested separately in the next section. If you do not consent to being filmed or photographed, you will not be recorded and your data will not be used in any public-facing output.

Participation in this study is entirely voluntary. You are free to withdraw at any time and without giving a reason, and you may choose not to answer any individual questions. You have the right to request access to any personal data held about you, and to request its correction or deletion where applicable and where you can be identified.

If you have any questions about this study, please contact Jop Alofs at .....

In the following section, you will be asked to provide your explicit consent for participation and for the various uses of your data.

## 7 Finding the right format

This paragraph describes the findings from two experts from the maker movement. I first interviewed, Renée Marcelis, she is creative director at the Bouwkeet, a maker space for children in Rotterdam. I also talked to Jerry de Vos. Currently, working on the open-source hardware project at the TU Delft and has worked on the precious plastics project and the open-source plastic scanner. Renée had many ideas on how to create awareness where Jerry had more experience on creating an active maker community around a concept, this was their advice:

- Renée immediately recognized that this project was about awareness. This could be achieved in the form of popups at busy location like Rotterdam Central station or a stand at the Dutch Desing Week.
- Finding a partner that can benefit from this concept is essential, working together with for example, the NS or municipalities.
- She also said that adoption is difficult with making projects. People won't go out of their way to make something for their bike if they weren't already motivated to do so. Therefore the concept should be situated in a place with bike traffic where people can be surprised. This is when people tend to reflect on their experience the most, according to Marcelis.
- Marketing strategies are needed to make the concept more attractive.
- De Vos mentioned how there are many ways to spread an open source product. From very technical

platforms like Github to Instagram pages that are mainly focussed on awareness.

- Defining the goal of the project is important to choose the right platform.
- But in all cases they only work if there is an active designer or community.
- Good pictures and a visual style were very important to the success of the Precious Plastics project.
- A polished visual style can invite people to make their own version of the product. On the other hand it can be a barrier for people to share their own work.
- Instructables is a good platform if you want makers to find your project by accident. Social media is less effective for this purpose.
- An social media page that is not up to date has less credibility compared to a dedicated website or a post on a website like Instructables. This is important, because low activity can lead to a lack of engagement from the community.

## 8 Break-even point calculations

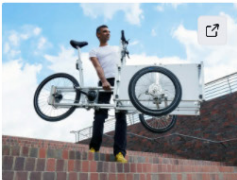
Upkeep Bicycles - Chain Guard Workshop						
Break Even Point Calculations - Workshop capacity: 4-8 participants (6 used for calculations)						
	Unit price (€)	Bike Shop	Bicycle Kitchen	Maker Space	Pop-Up (rental)	Comments
<b>INVESTMENT COSTS</b>						
Machine		€500,00	€500,00	€500,00	€500,00	
MDF Mould		€20,00	€20,00	€20,00	€20,00	
Dremel Tool		€55,00	€55,00	€55,00	€55,00	
Dremel Jig + Bit		€5,00	€5,00	€5,00	€5,00	
Hand Tools (6x)						Per person tools below
Sheet Scissors	€9,00	€54,00	€54,00	-	€54,00	
Tape Measure	€2,00	€12,00	€12,00	-	€12,00	
Drill (4x)	€30,00	€120,00	€120,00	-	€120,00	
Drill Bits	€2,00	€12,00	€12,00	-	€12,00	
Files	€2,00	€12,00	€12,00	-	€12,00	
Allen Keys	€5,00	€30,00	€30,00	-	€30,00	
Van		-	-	-	€1.500,00	Pop-up only
Tent		-	-	-	€200,00	Pop-up only
Portable Battery		-	-	-	€160,00	Pop-up only
<b>TOTAL INVESTMENT</b>		<b>€920,00</b>	<b>€820,00</b>	<b>€580,00</b>	<b>€2.680,00</b>	
<b>MATERIAL COST PER PRODUCT</b>						
Plastic sheet		€5,14	€5,14	€5,14	€5,14	vinylkunststoffen, large influence on BEP
Stickers		€0,05	€0,05	€0,05	€0,05	
Plastic for brackets		€2,13	€2,13	€2,13	€2,13	
Hardware		€0,82	€0,82	€0,82	€0,82	
<b>TOTAL MATERIAL / PRODUCT</b>		<b>€8,14</b>	<b>€8,14</b>	<b>€8,14</b>	<b>€8,14</b>	
<b>PER-WORKSHOP ECONOMICS (6 participants)</b>						
Labour cost	€15,00	€90,00	-	-	-	- Paid labour only for bike shops
Selling price	€15,00	€15,00	€15,00	€15,00	€15,00	
Cost per workshop		€78,83	€48,83	€48,83	€48,83	
Income per workshop		€90,00	€90,00	€90,00	€90,00	
<b>PROFIT PER WORKSHOP</b>		<b>€11,17</b>	<b>€41,17</b>	<b>€41,17</b>	<b>€41,17</b>	
<b>BREAK EVEN POINT</b>						
Number of workshops		<b>73</b>	<b>20</b>	<b>14</b>	<b>65</b>	
Number of chain guards		<b>440</b>	<b>119</b>	<b>85</b>	<b>391</b>	

## 9 Overview of stakeholder meetings


During this project, I was privileged enough to get advice from a lot of people. In this overview, I wanted to show who I met and what they helped me with. Their feedback helped me to get out of the concept phase and ground my project in the real world.

Contact person	Location	Purpose	Date
	Bike shop Lifecycle Delft	Get repair insights	28-9-2025
Renée Marcelis	Bouwkeet Rotterdam	Learn about teaching children repair	1-10-2025
Florian	DIY fietswerkplaats Rotterdam	Bicycle kitchen	1-10-2025
Eduard	Bouwkeet Rotterdam	Seeing how children repair	8-10-2025
Coby Passchier	Email	Get data bicycle municipality services	8-10-2025
Martijn Hoek	Bike repair school Den Haag	Learn about industry and education	16-10-2025
Ghassan Alagourie	Online interview	Gain industry perspective	20-10-2025
Bas Flipsen	Email	Repair research insight	25-11-2025
Ackermann	Email	Product care research insight	7-12-2025
Theunis van Woestijne	Email	Manufacturing advise	21-1-2026
Renée Marcelis	Bouwkeet Rotterdam	Getting feedback on the concept	28-1-2026
Jerry de Vos	TU Delft	Finding the right format for the website	3-2-2026
Jerry de Vos	Email	Feedback website	3-3-2026
3 people	TU Delft	Bike repair interviews	

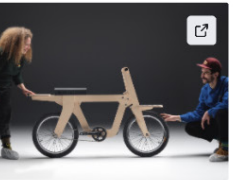
## 10 Existing DIY bicycles



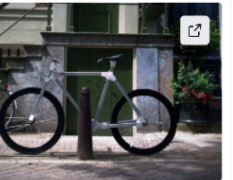
**XYZ CARGO - Modular and Sustainable Cargo Bikes**  
Strong, lightweight, and affordable cargo bikes. By N55 and Till Wolfer



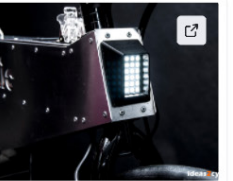
**DIY Wooden Bicycle - Make:**  
Swedish industrial designer Erik Björk built this fantastic Do It Yourself Wooden Bicycle.




**Plywood Bicycle Makes Frame Building M...**  
Bike frames are simple on the surface, but can quickly become complicated if you want to fabricate one yourself. Brazing and welding tend to be l...




**The OBI 0.5 is a 3D Printed Open-Source Bicycle**  
Forget the bus. No more cramped tram. The Open-Source Bicycle is the best use of your 3D printer this season.




**The Indie Project - ideas2cycles**  
Published 2014-05-06



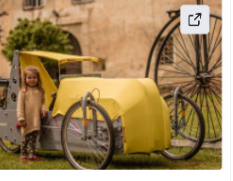
**Quirky assemble-it-yourself bike is sure...**  
If you like putting things together and you like getting noticed, then you'll probably like the Bellcycle. Created by New York City-based cyclist Alex Bell...



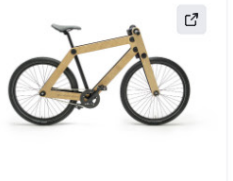
**Reframed bike costs under \$200, but s...**  
While a lot of people would like a simple no-frills bicycle for basic transportation, they also don't want a poorly-made piece of junk. That's where the D...



**BETTER TO TRANSPORT BTT. - The Science Gall...**  
BY THOMAS HOOGEWERF NETHERLANDS 2019 HOW CAN WE USE PLASTIC WASTE IN A PRODUCTIVE WAY? Better To Transport is a tricycle...



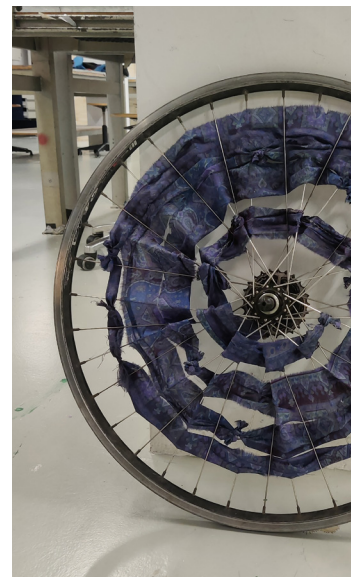
**motofocker velocar combines bicycle and...**  
the motofocker velocar, developed by maté foc, is a three-wheeled human-electric hybrid vehicle positioned between a bicycle and a car.



**Sandwichbike Wooden Fork 1-speed Ready...**  
The award winning Sandwichbike is not just a bike, it is a statement! Cruise around town, chill in the park and flirt on the boulevard. Feel the excitement...

## 11 Examples of bicycle customisation

During this project I kept track of all the DIY bicycles that stood out to me. These are bikes from friend, bikes that I repaired myself, and bikes that I saw standing in the city or in the bicycle parking at university.





## IDE Master Graduation Project

### Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

### STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Alofs	IDE master(s)	IPD <input checked="" type="checkbox"/>	Dfl <input type="checkbox"/>	SPD <input type="checkbox"/>
Initials	J.P.	2 <sup>nd</sup> non-IDE master			
Given name	Alofs	Individual programme (date of approval)			
Student number	5055350	Medisign	<input type="checkbox"/>		
		HPM	<input type="checkbox"/>		

### SUPERVISORY TEAM

Fill in the required information of supervisory team members. If applicable, company mentor is added as 2<sup>nd</sup> mentor

Chair	J.W. Hoftijzer	dept./section	HCD / HF	<p>! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.</p> <p>! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.</p> <p>! 2<sup>nd</sup> mentor only applies when a client is involved.</p>
mentor	Freerk Wilbers	dept./section	SDE / MF	
2 <sup>nd</sup> mentor				
client:				
city:	Delft	country:	The Netherlands	
optional comments				

### APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in by the Chair of the supervisory team

Sign for approval (Chair)

Name JanWillem Hoftijzer Date 1 oktober 2025 Signature

Personal Project Brief – IDE Master Graduation Project

Name student Jop Alofs

Student number 5,055,350

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

**Project title** Designing a DIY bicycle: How making can improve the user-product relationship.

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

**Introduction**

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

The world is saturated with cheaply produced commodity goods. Mass production on the other side of the world has led to a significant distance between people and production. Consumers are continuing to lose their understanding of how products are manufactured and the resources that are used to make them. This detachment, combined with a consumer culture that is driven by companies focussing all their efforts on increasing their revenue, has worsened our user-product relation. This cycle needs to change if we want to free ourselves from the consumer society and create a sustainable future.

In recent years, this awareness has surfaced both among consumers and within the design community. The maker movement demonstrates that there is a group of people interested in making, repairing and modifying the products around them. Within the design community this has led to the conception that consumers could be made part of the design process. In other words, design should be accessible and open to all. As a response to this vision, Hoftijzer created a framework aiming to assist designers in the design for do-it-yourself (DIY) process.

This thesis applies the 'Design-for-DIY' framework to the design of a city bike tailored to the Dutch context. The goal will be to create awareness about the lost user-product relation among cyclists. It concludes with a reflection on the method used and on the broader field of "design for DIY."

→ space available for images / figures on next page

introduction (continued): space for images



Scale models of Enzo Mari's Autoprogettazione: One of the first examples of Design-for-DIY

image / figure 1

## Personal Project Brief – IDE Master Graduation Project

### Problem Definition

*What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.  
(max 200 words)*

Bike sharing and leasing platforms have gained traction and in many ways this is a reflection of the worsened consumer-product relationship in our society. Companies like Swapfiets are offering customers the guarantee that they will always have a working bicycle. People are purposefully detaching themselves from the job of maintenance and repair and therefore bikes are becoming a commodity. Users seem to trade the appreciation for the product and its aesthetics with convenience and functionality.

Today's bikes are already repairable and ready for DIY. But factors including: different standards, the need for specialty tools and a lack of knowledge among others mean that users don't usually interact with bikes in this way. Design for DIY could help solve this problem.

This project will not focus on people's willingness to perform repair and DIY activities, but will rather look at the effect of DIY on their understanding, and ultimately attachment with the bike that they use every day. The goal will be to reimagine what a bike is. A critical design approach will help to answer the question how design for DIY can help to strengthen the user-bike relationship.

### Assignment

*This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:*

*Design a bicycle that uses the principles of design for DIY to reduce product alienation and strengthen commuters' awareness of their relationship with their bike.*

*Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)*

During the first stage of this thesis I will use a speculative design approach to broaden my understanding of the subject and have something to talk about with users. I will also conduct various interviews with users and industry to create a broad picture of the context. The qualitative data gathered from these interviews will help understand what intervention will be most effective in improving the user product connection.

In the next phase of the project, the Design-for-DIY framework will be used as a guide to create a product that users can make and/or modify themselves. Make sessions will be held to test the product and make improvements if necessary.

### Project planning and key moments

To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting, mid-term evaluation meeting, green light meeting and graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).

Make sure to attach the full plan to this project brief. The four key moment dates must be filled in below

<b>Kick off meeting</b>	17 sept 2025
<b>Mid-term evaluation</b>	7 nov 2025
<b>Green light meeting</b>	16 jan 2026
<b>Graduation ceremony</b>	16 feb 2026

*In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project*

Part of project scheduled part-time	<input type="checkbox"/>
For how many project weeks	
Number of project days per week	

Comments:

### Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five. (200 words max)

I wanted to work on this project for two reasons. First of all I'm a maker at heart. I've been working as a TA in the PMB workshop at our faculty and there I have had the rewarding job of teaching students how to work with machines and solve problems on the go. The second reason is that I have the feeling that we are losing our connection with products. And if I compare for example my grandparents furniture with mass produced ikea products it is not hard to understand why. We are losing our understanding of the materials and what it takes to make the products around us and I believe Design-for-DIY could be a step in the right direction.

I see my thesis as a way to explore this field and form my own opinion on the subject while hopefully creating products that could strengthen the user-product relationship.

My learning goals are to improve my interview and co-creation abilities, to strengthen my research skills, especially how to synthesizing large amounts of data into clear conclusions, and to enhance the way I present my work, both in writing and through drawing.