iFixit Coffee Maker Toolkit

How we can provide the right tools and right knowladge to improve the maintenance and repair of full automatic coffee makers within the EU.

IPD Master Graduation project

Student

Felix Mauricio
Fraile Schumacher

Nº 4771397

Chair

Bas Flipsen

Mentor

Sagar Dangal

Company Mentor

Matthias Huisken
from iFixit GmbH

iFixit Coffee Maker Toolkit

How we can provide the right tools and right knowladge to improve the maintenance and repair of full automatic coffee makers within the EU.

In collaboration with iFixit GmbH

Felix Mauricio Fraile Schumacher
fraileschumacher@gmail.com

Master in Integrated Product Design
Faculty of Industrial Design Engineering
Delft University of Technology
www.tudelft.nl

Supervisory team:
Bas Flipsen (Delft University of Technology)
Sagar Dangal (Delft University of Technology)
Matthias Huisken (iFixit GmbH)

26 March 2021

Executive summary

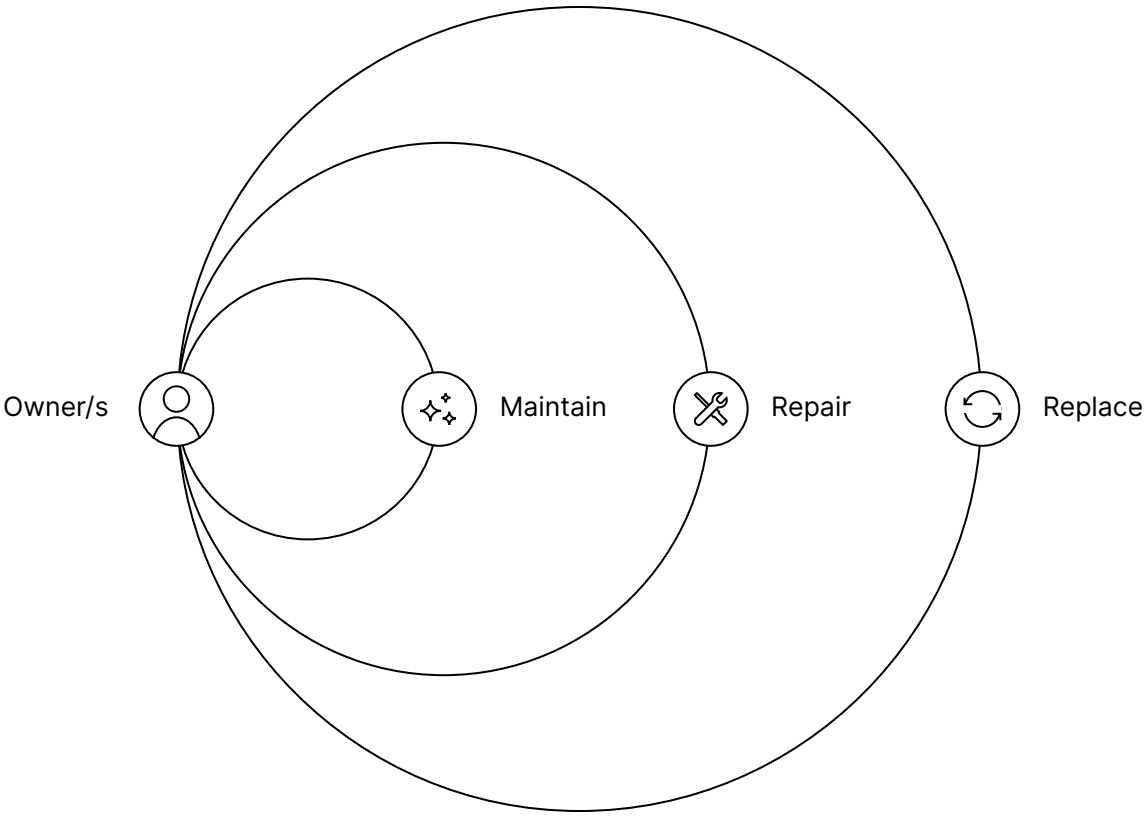
With e-waste being one of the fastest growing waste streams in the European Union. The notion that we need to reduce the amount of household electronics that end up in the landfill is becoming more and more relevant (Eurostat, 2020). Repair is the most efficient alternative we have, even when compared to re-manufacturing or recycling (T. Cooper, 2010), so in this project we are going to focus on how we can improve the repair experience of coffee makers. Since there are a large variety of coffee maker types, we decided to focus mainly on domestic bean-to-cup (also known as fully automatic) coffee makers. The reason behind this is that this type of coffee maker has a low repair cost when compared to it's replacement cost, meaning its way cheaper to repair it when it's broken rather than buying a new one (Mudgal & Tinetti, 2011).

This project focuses on how we can provide consumers with the right tools and the right knowledge so that they can take care of their coffee makers. The final outcome of this project is a toolkit that includes all the necessary items for maintenance and repair and a website to help consumers through the fault diagnosis process (i.e. help them find out what is wrong with their coffee maker).

For the toolkit we have analyzed 44 coffee makers from the top brands in Europe to get a general overview of what tools we need to incorporate. We then carried out multiple tests with participants during the research and ideation phase, this allowed us to verify that those tools cover all the needs people have during the repair process. Additionally, we interviewed a small number of bean-to-cup owners and experts to get insight into what desires and problems they expirience.

In that interview with the bean-to-cup owners, we detected that the fault diagnosis is one of the main barriers in the whole repair experience, so we developed a guide that relates the different symptoms a coffee maker presents to specific causes of failure. The core of this guide is a decision-tree which asks the user about certain symptoms and, with each answered question, reduces the number of possible faults. To make this decision-tree easier to navigate, we designed and tested a website that communicates those questions and instructions, so that we have a familiar medium which is easy to interact for newcomers. This has the potential to streamline the process and motivate people to try the repair by themselves, which is the ultimate goal.

Both the toolkit and the website have been tested to validate their value during the project, but the lack of resources and the ongoing COVID-19 pandemic have affected the number of coffee makers we had available and the number of participants we could gather. To further verificate the efficiency of this project, we would need to test the outcome with more models of coffee makers and people from different backgrounds and ages, preferably in person, after the pandemic is over.


Owner/s
Maintain
Repair
Replace

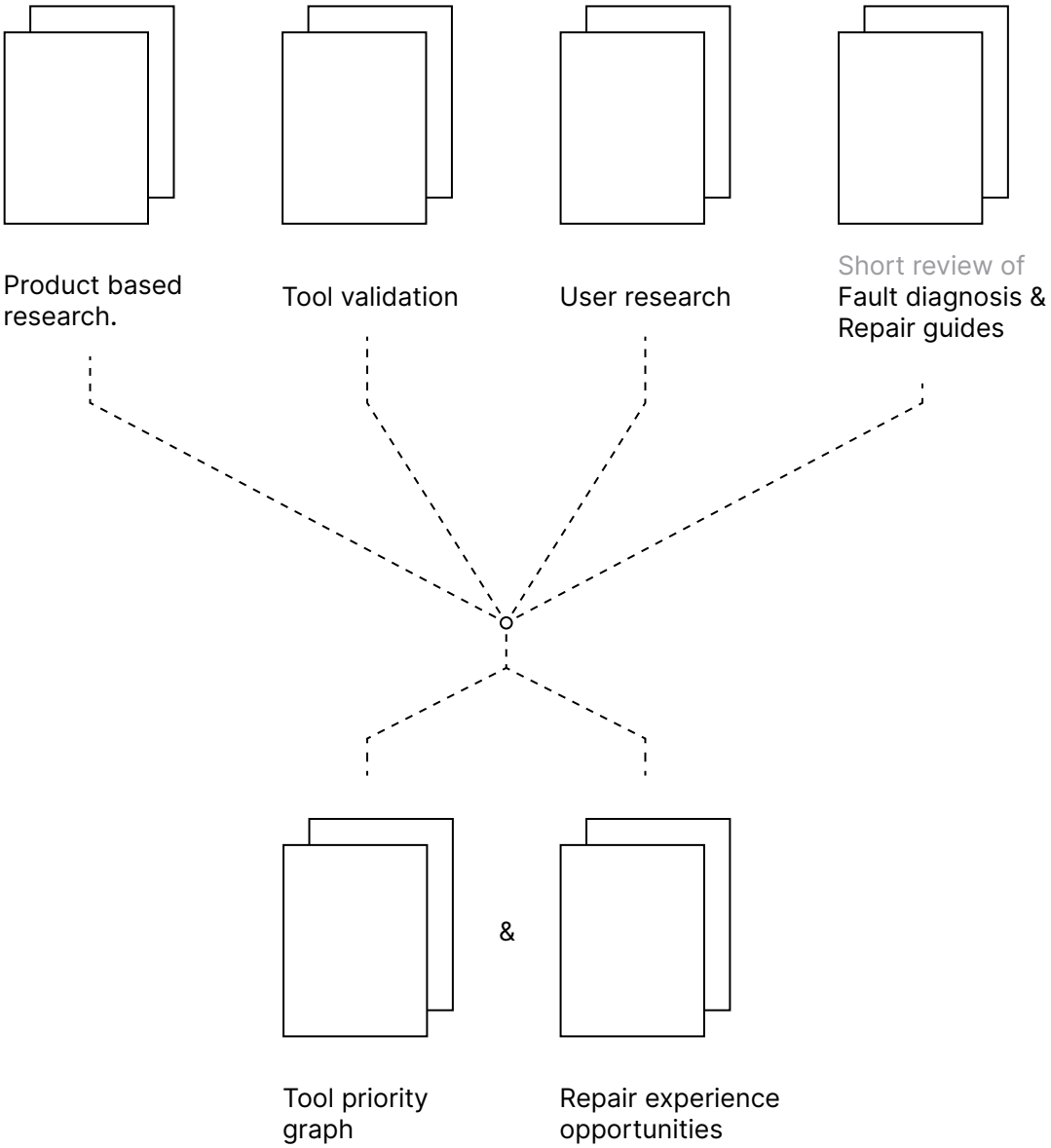
Even though our industrial economy has gone through significant changes since the start of industrialization, we have barely moved beyond our linear way of consumption, following a “Take, Make, Use & Dispose” resource model that has led to great environmental and social damage. In the wake of this realization, a new economic model is gaining more and more traction: the circular economy. This model has the goal of closing the resource loops and eliminating “waste” as much as possible from our system (Ellen MacArthur Foundation, 2013). One of the most efficient ways to close and/or slow those loops is via repair, since this method is more efficient in resource use when compared to other alternatives (within the circular economy) such as re-manufacturing or recycling (T. Cooper, 2010). Nevertheless, the practice of repair of household items has greatly decreased since the 1960’s, especially in Europe and America. McCollough (2009) exemplifies this via the employment drop in repair technicians from the 1960s to the 2000s, even if the household appliance industry has greatly increased at the same time. The growth in sales of household electrical and electronic equipment, combined with faster product obsolescence, has resulted in e-waste becoming the fastest growing waste stream globally (Cole & Gnanapragasam, 2017). This results in (small and big) household appliances being responsible for 62% of the total e-waste collected in Europe in 2017 (Eurostat, 2017).

From a governamental side, the growing problem of WEEE and the need to transition to a more circular economy, have pushed America and especially Europe to address the need to make products more durable and easier to repair. From the consumer’s side, the costs of planned obsolescence and its environmental implications are pushing the growing movement of “Right to repair”, which demands that products are easier to repair (Svensson et al., 2018). Additionally, the growing number of repair cafes, which offer a space for consumers to learn with others how to fix their household products, is empowering more and more people to attempt to repair their products rather than replace them. In a survey done at the UK, 60% of the participants said that after attending a repair cafe they were more likely to try to repair their household items in the future (Keiller & Charter, 2016). It is also important to mention that the activity of repairing and helping others to has a big potential in forming communities and empowering others to fix their items, both in repair cafes and online (Huston et al., 2016).

Cole & Gnanapragasam (2017), when they collaborated with the Restart Project in the UK, found that most people feel moderately or not at all confident in repairing the products they own. The lack of awareness, knowledge, tools, manuals or spare parts difficult the practice of repair for the average consumer. Total costs of repair, time, convenience, lack of trust, risk of poor quality and availability of cheap new products also makes repair a less competitive option (Svensson et al., 2018). Expected annoyances and frustrations due to the lack of experience can additionally discourage people into participating in the repair process (McCollough, 2009). In a survey carried out in South Holland, Dangar et al. (in press) found that the main barriers to repair for consumers were: that they didn’t know what was wrong with the product and that they didn’t know how to take the product appart. iFixit has been providing repair manuals, spare parts and tools since 2003 in order to help consumers and small businesses, with a focus on ICT, mobile phones and computers (Weetman, 2016). By collaborating in this project they can expand their portfolio to small household items like coffee makers.

The goal of this project is to improve the repair experience of coffee makers (in the EU market) by providing the right tools and knowledge. In this project we are going to focus on bean-to-cup and capsule machines since they are estimated to become more relevant, and the replacement cost is higher than the repair cost when compared to other models (Mudgal & Tinetti, 2011). In the first section of this document we can find the research that has been carried out to understand the coffee maker market and it’s consumers (page XX), this section includes the machine based research, the tool validation and the user research amongst other things. Followed by this, starting at page XX, we find the ideation process which has been divided into 3 prototyping and testing cycles (Inertia, 2020). And in the last section we can find the final result of the project, the next steps and the main conclusions.

Research 


Product based research.
Tool validation
User research
Short review of
Fault diagnosis &
Repair guides
&
Tool priority graph
Repair experience opportunities

1.1 Approach

The goal of the research section is to understand the specific needs from the coffee machines themselves (e.g. the type of screws they use) and the users (e.g. what type of information they need) when it comes to maintenance and repair.

The research section will be divided into multiple study units, each one of them with their own method and conclusions. At the end, the knowledge gathered by each unit will provide valid insight when merged together.

In order to achieve this we start with a machine based research, in which we analyze 44 coffee makers in order to get a general overview of the tools we need for this kind of product. After that we test those tools with users, where we ask them to disassemble and clean two coffee machines. This allows us to further define the tool selection and to discover needs and desires that may have not been detected in the machine based research. Following this, we interview current coffee maker consumers through the internet (due to the COVID-19 situation) to tackle the needs of people who have cleaned and repaired their own coffee machine in the past. Finally, we explore further into the literature of repair guides and fault diagnosis, since they are two relevant themes according to the previous units.

1.2 Product based research

Introduction

In order to be able to repair any kind of electrodomestic device, the first thing we need is the right tools to disassemble and access the parts that are dirty, damaged or completely broken. Additionally, keeping the coffee makers clean by carrying out routine maintenance is the best way to prolong the useful life of these products (Coffee Society, 2020) and avoiding mold, yeast and other threads to human health (NSF, 2011). If we want to provide a toolkit for consumers to maintain their machines, we need to make sure that we cover a wide variety of models and brands within the EU market. This means that we need to find out what exact tools are needed for each model and what the tool variety is, I.e. how different one model from the other is in terms of necessary tools. In conclusion, our main research question is: What are the most relevant and popular tools when it comes to accessing the path of entry* and maintaining coffee makers?. As mentioned before, this research applies mainly to the EU coffee market, with a focus on bean-to-cup machines and capsule machines due to their increasing relevance.

Legend

- Torx & Security Torx
- Philips
- Oval screw
- Flathead
- Other...

- Easy to pry
- Medium to pry
- Hard to pry

(m) indicates the need for multiple pryers

Method

To figure out what models we need to analyze we have to start with the most important brands and manufacturers of coffee makers in the EU. Dietlinde Quack (2011, p. 25) published a list of top coffee manufacturers in her research for the Oko Institute for Applied Ecology. By comparing this list with the key manufacturers mentioned (in the free summary section) of more recent market analysis, we can come up with an updated list of manufacturers for this research. The market analysis reports used for this are Global Coffee Machine Market Overview 2017-2030 (Goldstein, 2020) and Europe Automatic Coffee Machines Market Research And Manufacturers Analysis Report 2019-2025 (Future Market Reports, 2019).

The models analyzed for each brand are chosen on popularity and data availability. The main source of information for this research are YouTube repair videos. Based on observation, the information the uploader provided and the comments, the necessary tools for each model are written down. Other consulted sources of information used to validate the findings (while much less common) are service manuals and part diagrams.

For screwdrivers, the type and the size is noted. If the size cannot be identified an interrogation sign is present next to the screw type. If a coffee maker model requires prying tools or spudges, the difficulty of the process is marked as easy, median or difficult. This rating is based on the force required to open the model, and the simple three-level rating has been chosen since the evaluation is purely based on observation, for lack of a more accurate source of information. The list of sources used can be found at XX

jura

Jura E6
- T15, T20
- Oval

Jura D6
- T10, T15
- Oval
- ?

Jura A1
- T15
- Oval
- ?

Jura E8
- T10, T15, T20
- Oval

Jura GIGA
- T10
- Oval
- Plyers

Jura ENA8
- T15
- Oval
- Easy

DeLonghi

PrimaDonna
- T?, T20H
- PH2
- Easy (M)

Eletta
- T20H
- PH2
- Easy (M)

Magnifica
- T?
- PH?

Perfecta
- ? (PH2)

Latissima
- T?H, T15H
- ? (?)

Citiz
- T10
- Oval
- Medium
- Tweezers

KRUPS

Barista
- T15H & T?
- ?
- Easy

Evidence
- T?

Master
- T?
- Easy

Expert
- T10H
- Medium (M)
- Oval
- Plyers

Atelier
- T? & TH?

Pixie
- T15
- Hard (M)
- Tweezers

PHILIPS

Picobaristo
- T10 & T?
- ?

Xelsis
- T10, T15, T20
- ?

Senseo
- T15
- ?
- Hard (M)

2200
- T8, T10, T?
- Medium (M)

3200
- T10, T?
- Medium (M)

5000
- T8, T10, T?
- Easy (M)

BOSCH

VeroCafe
- T10
- Hard (M)

VeroCup
- T20 & T?

Miele

CM5000
- T15 & T20
- Medium (M)

CM6300
- T10
- Medium (M)

Tchibo

Esperto Caffè
- T?

NESPRESSO

Prodigio
- T10H
- Medium

Serie U
- T?H
- Easy

Vertuo Next
- T10H, T?H

NIVONA

CR 740
- T10
- Easy

CR 830
- T10
- 3mm
- Easy

Melitta®

Barista
- T10
- PH2
- 3mm
- Easy

Lattea
- T10
- 3mm
- Easy

Solo
- T10
- 3mm
- Easy

Bistro
- T10
- PH2
- 3mm
- Easy

SIEMENS

EQ.3
- T?
- Hard (M)

EQ.6
- T20
- ?
- Hard (M)

EQ.9
- T15
- ?
- Hard (M)

AEG

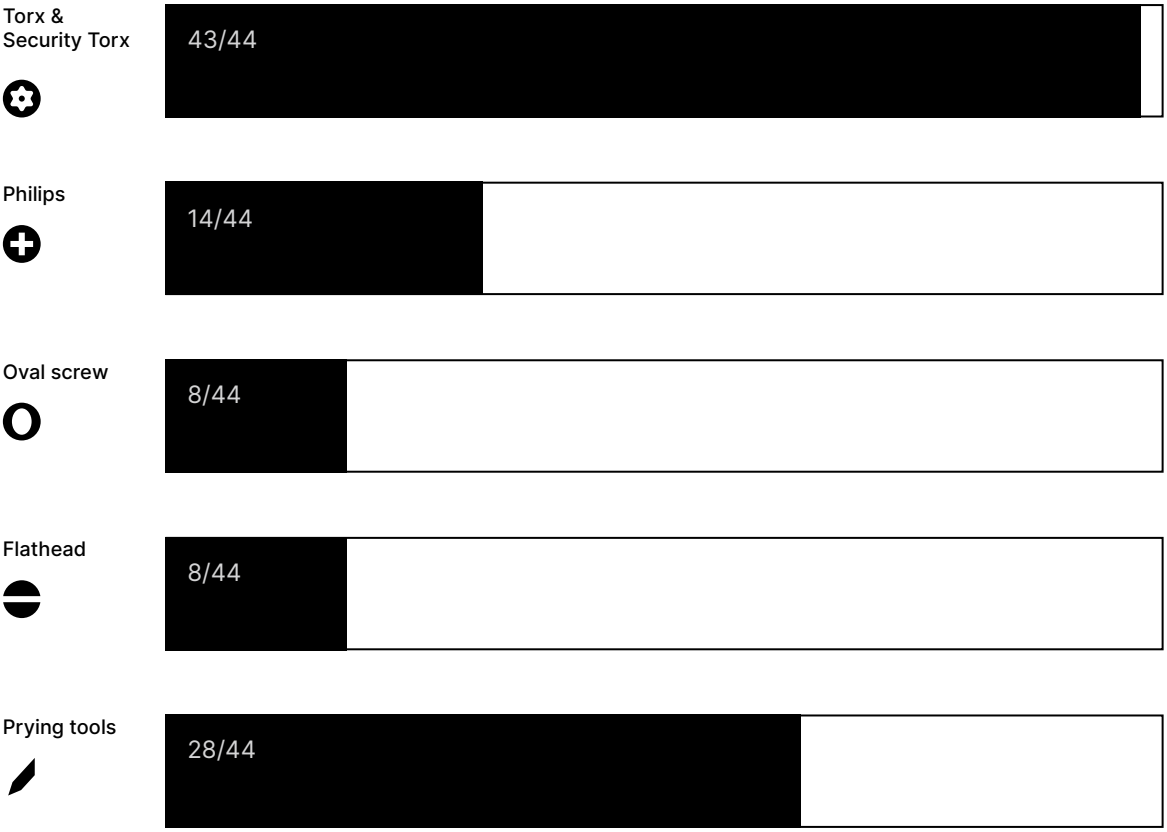
CS 5000
- ?
- ?
- Easy

CaFamosa
- ?
- ?

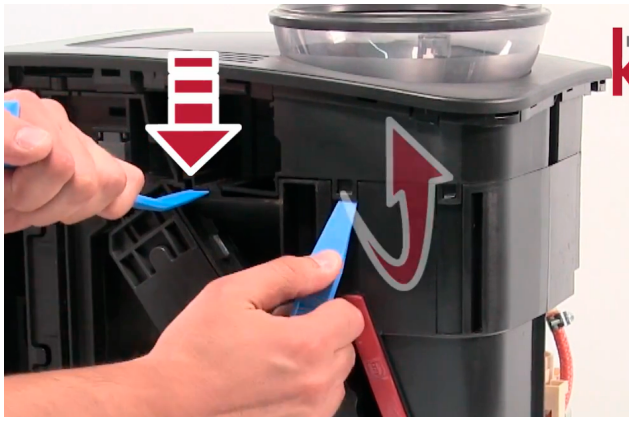
Build-in
- ?
- ?

Results

Screwdriver types



Prying requirements

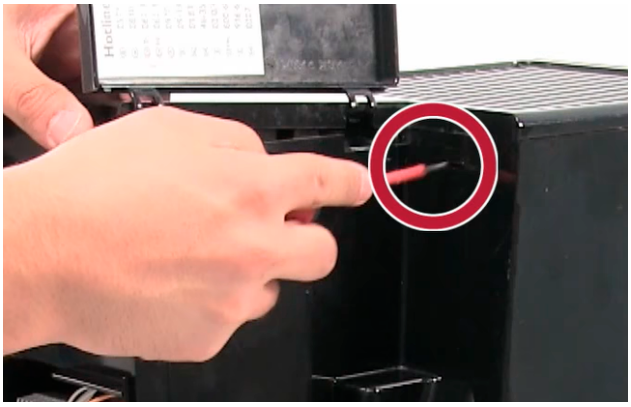


1. Able to apply considerable force without breaking.

Some machines are very hard to pry open because the plastic parts have multiple snapfits that require a lot of force to free up. Usually flathead screwdrivers are used as prying tools because the standard plastic spudger can’t apply such force without breaking. It is that the toolkit includes a prying tool that is able to apply and resist such force without breaking.

2. Flat enough to fit in the small gaps between plastic parts.

Prying tools are mostly inserted in the gap formed between two plastic parts, and that gap can be quite narrow. That means that the prying tool needs to be “sharp” enough to fit in the gap and push the two parts open.

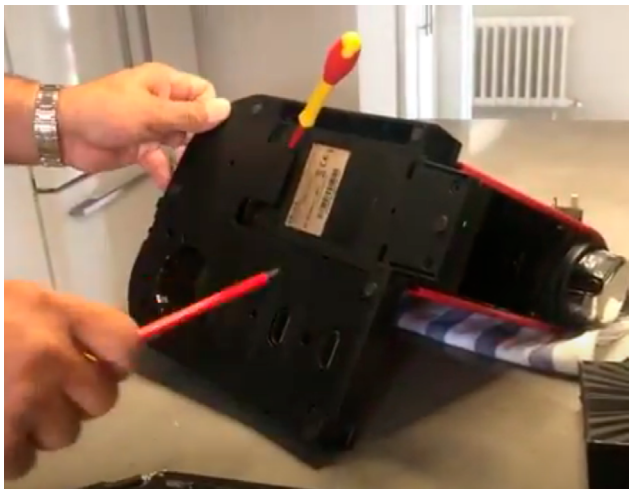


3. Small width to fit in the snap fit slots.

Some machines are very hard to pry open because the plastic parts have multiple snapfits that require a lot of force to free up. Usually flathead screwdrivers are used as prying tools because the standard plastic spudger can’t apply such force without breaking. It is that the toolkit includes a prying tool that is able to apply and resist such force without breaking.

4. Avoid damage to the plastic parts.

Prying tools are mostly inserted in the gap formed between two plastic parts, and that gap can be quite narrow. That means that the prying tool needs to be “sharp” enough to fit in the gap and push the two parts open.



5. Additional pryers to keep the housing open.

Some coffee maker structures need multiple pryer tools in order to be disassembled comfortably. Usually those structures incorporate multiple snapfits that snap back into place if they are not held open.

Cleaning

While cleaning tools were originally not within the scope of this research, while observing such a wide variety of repair videos, a variety of tools have been detected during the cleaning process.

Conclusion & Next steps

When it comes down to screwdriver types we can see how torx and security torx are the most used, being present in 97,7% of the models analyzed, usually between the sizes of T10 and T20 on the ones where the size could be identified. Although some internal parts of Jura machines also use T8 and T9 screws (Jura-parts.com, 2020). Philips screws are in second position of usage popularity, especially in DeLongui, Philips and AEG models. The third screwdriver type that the toolkit needs to include according to the analysis is the Oval screw, used in Jura and Nespresso machines. This type of screw is a one-size screw used exclusively in coffee machines to prevent users from repairing the machines themselves (C. M. Lott, 2010). Additionally, flathead screws are used in some instances, but they are mainly used to loosen snapfits. Nevertheless, as mentioned in Kontra forums, some professional espresso coffee makers from Simonelli and La Marzacco (not analyzed in this research) use flathead screws to secure the metallic filter to the grouphead. Another thing present in the repair videos is the use of long and rigid screwdriver extenders and screwdriver shafts.

For prying tools and spudgers we've assembled a list of requirements (as seen in the findings section) that we need in order to open up the selected coffee makers. Currently there isn't an iFixit tool that complies with all the listed requirements, so the next step should be to test the current spudgers and prying tools on a number of coffee makers. This would allow us to see if we can include a combination of iFixit prying tools in the toolkit or we need to develop a new type of tools especially designed for prying open coffee makers.

While this analysis has been successful to detect what kind of screwdrivers and prying tools we need, it provided little insight into what cleaning tools are needed. Analyzing cleaning tools was not part of the initial goal of this unit but the videos have proven that they are relevant for the maintenance process. From the information provided by the manufacturers we know that periodically descaling and cleaning of the brewing unit is essential for a long useful life of the product. Additionally we need to lubricate the brewing unit when the o-ring gets worn out or the machine hasn't been used in a long time (Coffee Friend, 2020). When it comes to removing coffee grounds, consumers use a wipe and water for cleaning, but some areas are hard to reach or cannot be cleaned with running water, so we need a brush to remove coffee ground particles. In the next research step we should explore what kind of brush is more successful in cleaning the internal parts of the coffee makers.

1.3 Tool validation

Introduction

The product based research has been successful in identifying what kind of screwdrivers the toolkit needs to include and what properties the prying tools need to have. But other matters like cleaning need further development, which is not possible by solely analyzing the machines themselves. In this unit we are going to test with users the selected tools, looking into how they navigate the repair process and what needs and desires arise for each category of tool.

The test participants will need to disassemble, clean, replace a part and assemble again two coffee makers: a Jura ENA7 (bean-to-cup) and a Nespresso Pixie (capsule). According to the machine based research, the Jura machine will present challenges when it comes to cleaning and using the screwdriver with the extender, while the Nespresso machine is going to put the prying tools to test.

By disassembling and analyzing these coffee maker models we can further address the questions that couldn't be answered by the machine based research and validate our findings. The main questions are the following:

- Can we include current iFixit prying tools or do we need to develop a new one.
- Is the flexible iFixit extender precise enough to access hard-to-access screws or do we need a rigid version.
- What cleaning tool is most efficient to remove and collect coffee ground residue.

Additionally, at the end of the test we will ask participants if they have any additional desires when it comes to tools and information.

Method

Before we start testing with external users, we will disassemble the machine ourselves in order to get to know the models and see which are the critical steps in the repair process. This can also help us see what risks or difficulties could come up for the participants. The participants of this research will be student colleagues and friends, since in times of COVID-19 the possibility of inviting external coffee maker users is too risky.

Their task will be to pry open the case, use the screwdriver extender and clean the coffee grounds using the both methods available in each case (three in the case of cleaning). The test setup will include the 2 coffee machines, a laptop with a repair guide and the tools they need to use. Their objective is to replace the brewing unit for the Jura machine and the locking spring from the Nespresso machine. During this process they will be asked to think out-loud and comment on the barriers they encounter during the repair. At the end, they will be asked to comment on their overall experience and to grade each tool they used from 10 (very useful) to 0 (not useful).

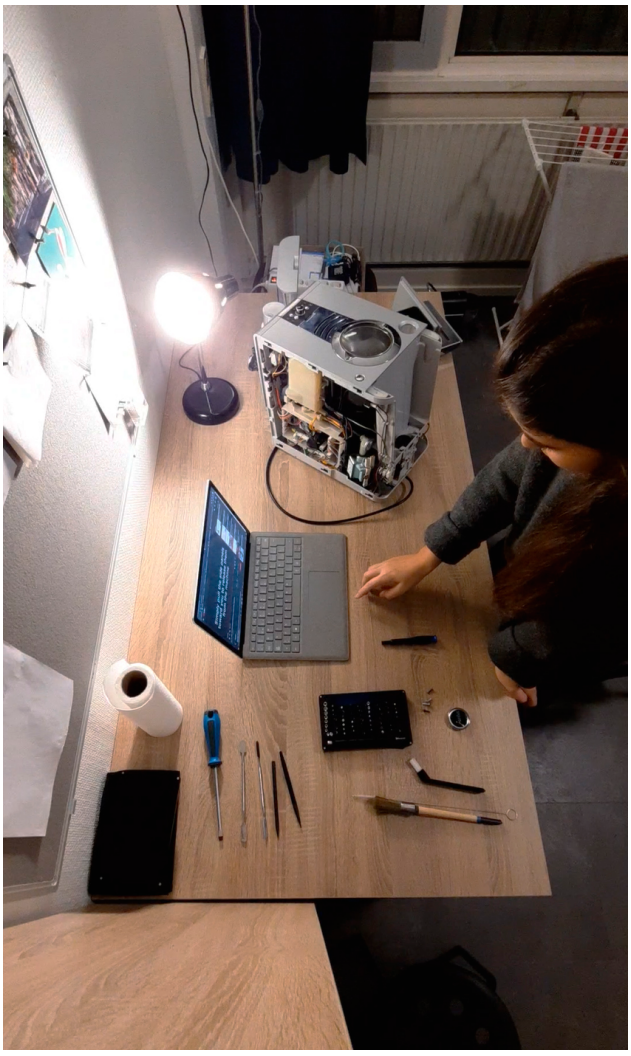
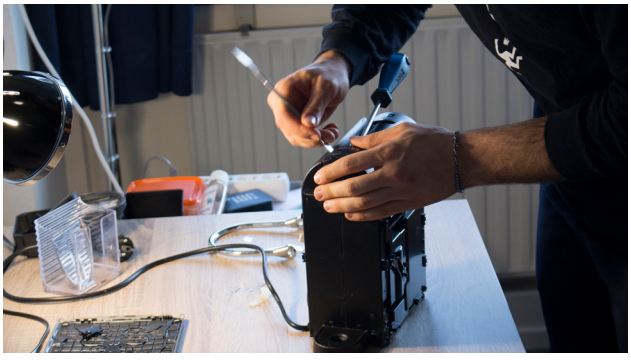


Fig. 0. Testing context



Results

Plastic spudger

2.4/10

Metal spudger
(triangle-shovel)

9.2/10

Metal spudger
(long shaft)

2.4/10

Screwdriver
(as spudger)

7.6/10

Front brush

7.2/10

Side brush

2/10

Cyclindrical
brush

2.4/10

Solid extender

10/10

Conclusion & Next steps

When it comes to the prying tools, the iFixit metal sludge (Shovel-to-triangle) was the clear winner amongst all the other prying tools. This tool is able to apply great force without breaking while, at the same time, enabling precise prying thanks to the shape of its ends: the triangle end is sharp and can fit in small gaps while the shovel end is more rounded and wide, which is better to apply more force and not scratch or damage the plastic parts. Nevertheless, the test participants mentioned that more than one prying tool is needed for those plastic casings with multiple snap fits, so secondary tools should be included. The second favorite is clearly the screwdriver, which incorporates an ergonomic handle and a long shaft, making it easier to apply greater forces. The plastic spudger was the first tool that was picked up at the start of the prying process, because users saw it as the least probable to damage the plastic parts. But as soon as they realize that the plastic spudge is not strong enough to apply the necessary force, they switch to a metal one.

When it comes to cleaning, most of it was carried out with a wipe or a papel towel, since this method both collects and cleans the water and coffee ground residue. The frontal brush was used to clean the spaces which were difficult to access, but a wipe is always necessary at the end of the process, since the brush doesn't collect the residue. None of the participants used the side brush or the cylindrical brush. When asked about it, they mentioned that the long handle and the soft hair of the frontal brush made it a much preferred option, and that in this case they didn't find it necessary to use the side or cylindrical brush. However, one participant mentioned that the cylindrical brush would be much better to unclog the nozzle of the coffee maker, which is an activity that wasn't included in this test.

One aspect all the participant agreed on is that a solid screwdriver extender is absolutely necessary. The current flexible extender is not precise enough to put the screw back during the reassembly process. Additionally, when the screw requires a lot of torque to unscrew (e.g. screws that are inserted directly into plastic parts rather than metallic inserts), the flexible extender tends to deform into a spiral shape, making it impossible to unscrew. Another insight mentioned by some participants is that the extender should be magnetized to make the re-assembly of screws more easy. If that is not the case, there is a need for tweezers in order to be able to put the screws back in place in difficult to access areas.

While the focus of this study was solely to analyze the use of tools, when asked about their experience at the end of the process, some also commented on other barriers unrelated to the tools. The fear of breaking plastic parts plays a major role in discouraging participants to continue with the repair process, which often happens when "clicking" sounds of the snapfits resemble the sound of plastic breaking. This has to do a lot with expectations set by the repair guide. In this case the video repair guide had music overlaid instead of the original sound, so the participants didn't know if the sounds they heard were a natural part of the prying process or an indication of plastic breaking.

3.1 User research

Introduction

The two previous units have been solely focused on the tools the user needs to disassemble, repair and clean the machines. But to improve the whole repair experience we also need to focus on other factors, like the knowledge the user needs to have. The main focus of this research is to investigate the current repair experience from the point of view of the coffee maker users, exploring what the current barriers and needs are that are not addressed. The study will be based on a series of questions addressing all the stages of the repair process: expirience, preparation, tools and information needed, the process itself, the context and the most frustrating moments overall.

We know consumers mainly decide if repairing a product is worth it based on the comparison between the repair and replacement price. But other factors as expected necessary time investment and the expected annoyances can play a role in consumers' attitude towards repair (McCollough, 2009). Additionally, apart from identifying the negative barriers of repair, it's also important to understand the motivations and benefits of the current repair experience. This allows us to understand (and change if desired) the current "value of repair" from the point of view of the consumers (Huston et al., 2016).

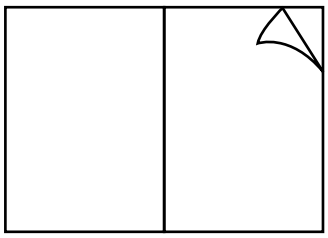
For this user centered research we are going to focus on both newcomers and experts in the repair world. This will allow us to understand what needs and desires change with time and experience. In conventional times this would be done via fieldwork, visiting the coffee maker's themselves. But in times of COVID-19 this research has to be adapted.

Method

We contacted participants via coffee maker specific forums: bean-to-cup.org, komtra.de and koffiepraat.nl. There we explained the purpose of the study, the length of the interview and where to contact us. After they reached out to us and agreed to participate we gave them the option to answer the questions via Skype, in a one-to-one interview, or to answer the questions via email (which was the preferred option for most of the participants).

Once we received the answer from all participants we arrange them in a journey map in order to visualize the insights according to each step of the repair process.

Results



Findings are represented as a journey map in the next sheet.

Participants:
Claud (UK)
Andy (DE)
Tobias (DE)
Benny (DE)
"Simon" (NL)

Conclusion & Next steps

While this user research falls quite short in the number of participants, it has provided useful insights in the common problems newcomers face when compared to experts. Additionally, there is a difference in the repair experience depending on the coffee maker model you own, since the availability of repair information and replacement parts comes dictated by the popularity of the model and it's brand. There is an opportunity to inspire the repair community to generate more repair guides for older or less known models, but this is out of the scope for this project.

What's clear is that newcomers rely much more on the information they find online and in service manuals, since they lack any experience or prior knowledge. On the contrary more experienced people and experts rely on their repair experience with other coffee makers and spend less time and effort in searching for information online. This also has to do with the fact that a lot of bean-to-cup machines have a similar structure. If you already disassembled a machine before, you are going to find very similar elements and fixing methods, even if your second machine is from a different brand. This eventually translates to a need for more accessible and precise information for newcomers, since any frustration during the initial search for information can become a motive to abandon the repair process.

When it comes to the medium of the information itself, video was preferred over text and image for the repair guides since it's easier to consume. Nevertheless, when re-assembling the device, some mention that it can be awkward to navigate the video backwards. One user mentions how with text and image you can translate the text with Google, but when you have a video in a foregin language you can solely base the repair on what you see, not what the person is explaining. There is an opportunity to integrate videos into text repair guides, gaining the benefits of both, but the creation of guides should still be accessible and easy for the repair community.

One of the most interesting steps is the fault diagnosis process. Finding accurate information when it comes to symptom-to-cause and product knowledge has a big effect on the repair experience of newcomers. Not having the right information or having just vague information can lead to a lot of frustration. This is due to the expectations created by the user, which are not met during the actual repair process. On the other side, having accurate information for your coffee model provides a sense of security during the repair experience.

Finding out what is wrong with the coffe machine.

Consists of googling the problems you encountered and hoping someone in the forum already had a similar problem. If the problem is common the service manual can also be helpful.

The satisfaction of this depends on how popular the coffee model is and how common the issue is. It's hard to find information on what is wrong, but people on forums are helpful and friendly.

Learning how to disassemble it.

Searching for "how to dissasemble [coffee model]" on YouTube and Google and hope someone has posted a good tutorial on your exact coffe maker model.

Good videos seem to be are rearlly available for coffe machines (or in another language). Some go with the learn-as-you-try philosophy, but photos are needed for the later reassembly process.

Disassembling the coffee machine

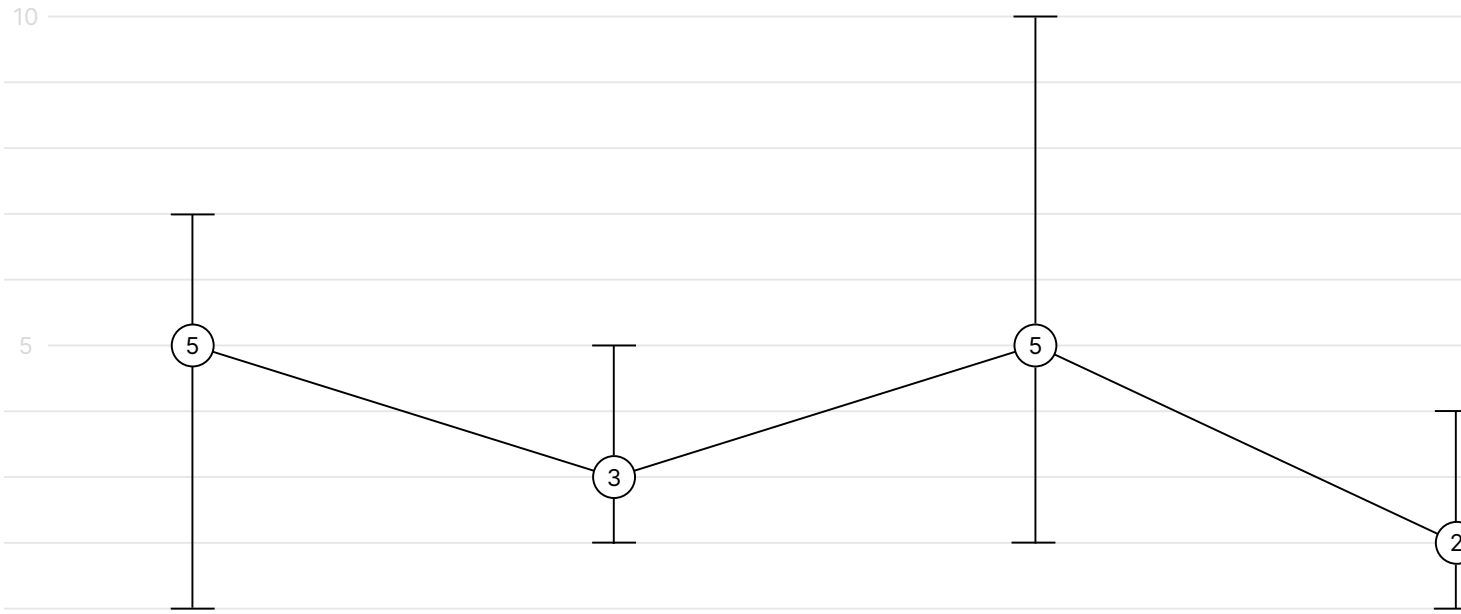
Taking apart your coffe machine until you reach the element you think is responsable for the malfunction.

If you found accurate information on how to disassemble your machine this step can be enjoyable. But otherwise it can take a lot of time to figure out how to take it apart without help.

Finding the fa element to re

Using your senses mation you found service manual) t component of the is cousing the ma

Depends on the a information you fo If you go blind, wi of what could be take a lot of time what element is re the failure of your



Google

Service manuals

Forum

YouTube

Repair guides (web)

Tools

Rotatory table

Light

Too

aulty pair/replace.

s (and the infor- online or in the o detect what e coffe machine lfunction.

ccuracy of the ound previously. thout any idea wrong, it can until you find out esponsable for machine.

Finding a replacement part to buy

If you can't repair the component with the tools you have, you have to buy (mostly online) the piece or component that is broken.

If you spend some time looking, you will eventually find some websit with the part you need. Its more difficult if your model is older or you are trying just to buy one small piece of a part, but they only sell the "whole part".

Re-assembling back the machine.

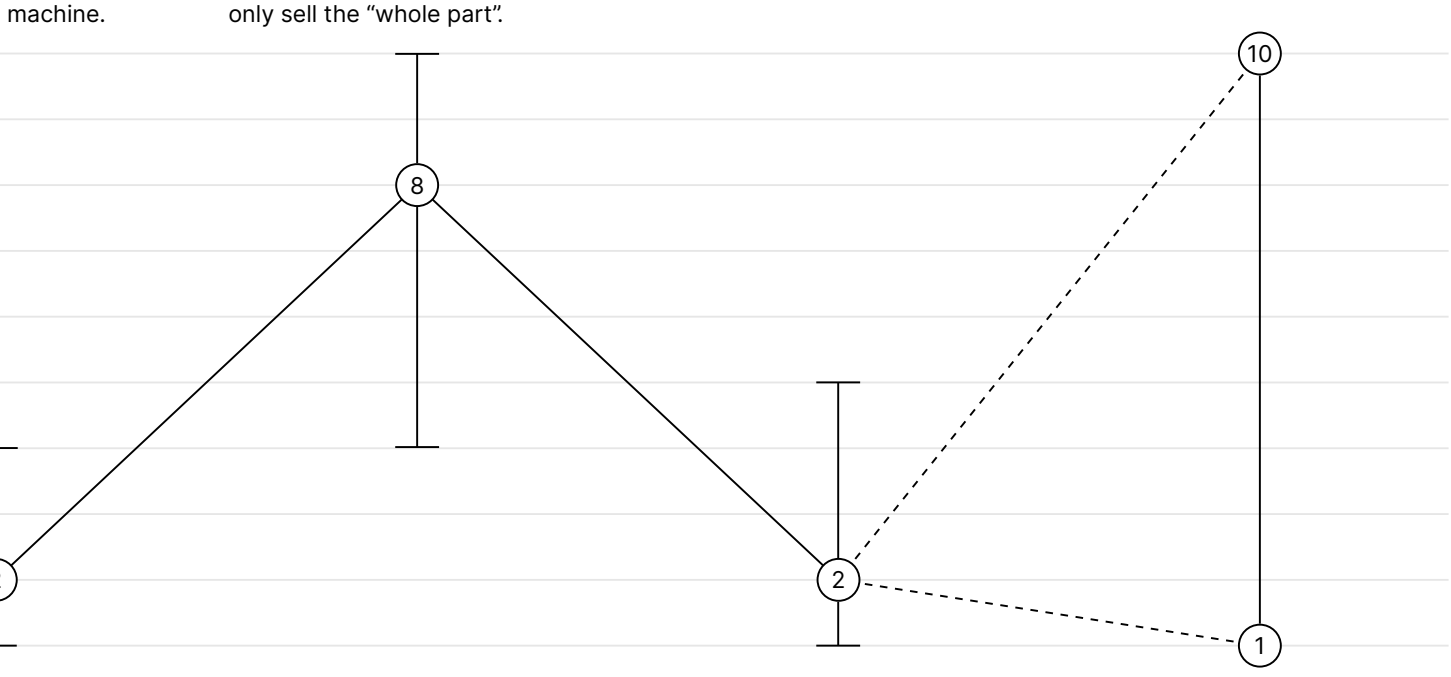
Putting back everything into place after you made the changes that you think are going to fix your coffee machine.

Can get very frustrating if you don't remember the exact sequence or you didn't take photos when you disassembled it. Even with the help of videos it still take more time than expected.

Testing if it works again after the fix.

Usually consist of turning the machine on and pouring a coffee to see if it works. On some occasions it also means tasting the coffe to see if it tastes good.

If it works it's very satisying. But if it doesn't, and you spended money on a new part for nothing, then it's extremely frustrating. Also this means that you have to start again from zero.



This section repeats itself if the problem was not fixed.

ols

Google

Provider website

YouTube

Repair guides (web)

Tools

Forum

1.5 Short review of fault diagnosis & repair guides.

FAULT DIAGNOSIS

Fault diagnosis is the process of determining which fault occurred, in other words, finding the root(s) that altered the correct functioning of a certain device (Ardakani et al., 2016). This term is often used in the field of computer engineering to describe systems that are able to detect faults on their own, but in the case of household repair this process has to be carried out by the consumers themselves, who often have little knowledge about the technical aspects of coffee makers (S. Dangal, in press). Most new coffee machines incorporate a Self-Diagnosis System that is able to detect simple problems and communicate it to the user via error codes (JennAir, 2020). But if the fault cannot be detected by the machine's Self-Diagnosis System it's up to the user's problem solving skills to find it and repair it.

Pozos et al. (2020) explains how the fault diagnosis process starts with a symptom of malfunction, which is how the user becomes aware that the product is not working correctly. Starting with that first symptom the user searches for other symptoms that can help him/her locate the fault. The efficiency of this process relies heavily on the user's symptom-to-cause knowledge, product information, the user's history with the product itself, and his/her past repair experience with other devices. From that point on, the user tests different elements/parts of the product to locate the fault itself.

Mainly, fault diagnosis requires an ability to combine repair experience and technical knowledge to relate symptoms to specific parts or systems of the product. Obtaining the right technical and symptom-to-cause knowledge is essential to the fault diagnosis process, since a user's lack of experience makes the lack of knowledge one of the main barriers to the repair process (S.Dangal, in press). Currently, the necessary knowledge can be extracted from service manuals and repair forums. The problem with these is that, for the first, the troubleshooting pages of service manuals can be quite oversaturating and hard to understand for newcomers (based on user research), besides the point that some service manuals can be hard to find online if the model is older. Repair forums are a prefered alternative for many, since they can talk with an actual person, with whom they can easily communicate. Additionally, people who answer in forums are usually experienced in the field or have faced similar issues in the past. The main disadvantage of forums is the question-to-answer time, which can cause enough frustration to the user to opt for abandoning the repair. The availability of good repair knowledge plays a key role in the repair experience, that is why reducing cognitive overload and providing detailed and fast answers to the users issues plays a major role in reducing frustration during the fault diagnosis process.

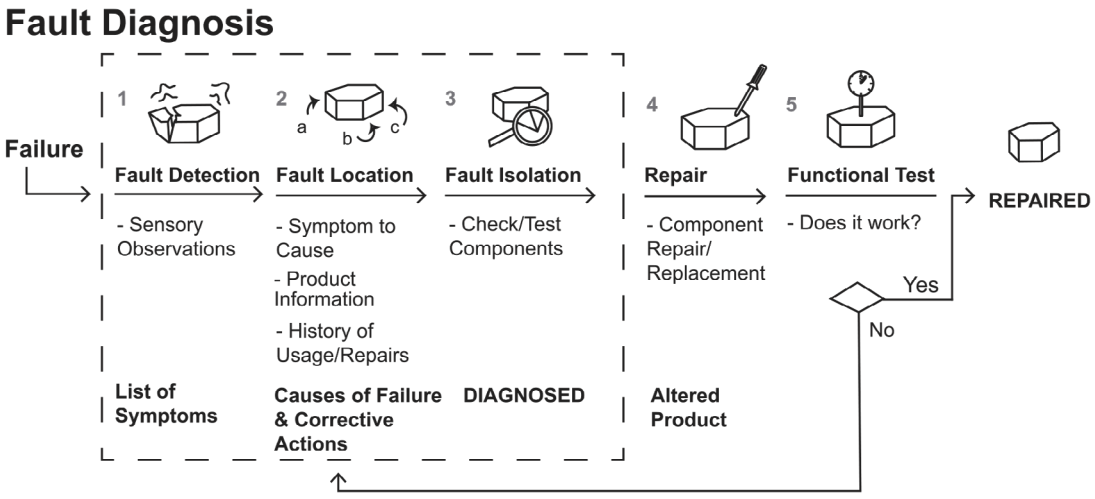


Fig. 1. Conceptual framework of the process of fault diagnosis.

B. Pozos et.al., 2020

REPAIR GUIDES

A repair guide is essentially any document that provides information on how to fix something. As exemplified by Michell (2018), in the 80s, some products like TVs came with repair information provided by the manufacturers themselves, serving as a knowledge source to carry out simple repairs. But as consumer culture has evolved, corporations have become more and more reclusive about any technical information about the structure or functioning of their products (which are essential to the repair process), to the point of taking legal action to those who distribute any information they deem as “sensitive” to the company’s interest.

Thanks to the rise of the internet, consumer communities and tinkerers started to publish guides and information online to help others repair their household items (Michell, 2018). Coupled with the increase of planned obsolescence (Cooper 2004) and disappearance of local repair shops (McCollough, 2009), online repair guides have become one of the most important information sources for consumers looking to repair their out-of-warranty products at home. The sense of community and partnership plays a big role in the creation of such guides (Huston et al., 2016), since most of them are created to share value rather than gain any monetary compensation. Most of them have a non-professional tone to them and use informal language instead of more technical lingo, which makes them appealing for consumers who aren’t experts in the field. As a consequence, it’s important to keep the importance of freedom of expression and community when proposing any significant changes to the repair guides.

With the rise of video sharing platforms such as YouTube (and more recently TikTok), video has become a much more desired medium when compared to image and/or text, especially for millennials and gen Z (lemonlight, 2020). The importance of sound and the capability to communicate more information in less time make it a much preferred option for newcomers in the repair world, as we have seen in the user research. Smartphones with good camera quality are also ever more common than before (statista, 2021), so the creation of content is also becoming more and more accessible. As seen during the Machine based research, there is already an existing and growing community of people uploading video content about coffee makers.

1.6 Tool priority graph

1. Bits & Driver

As the product based research has shown, without the adequate bits we are not able to start the dissassembly process.

2. iFixit metal spudger (shovel-triangle)

The iFixit metal spudger has proven to be the favorite prying tool thanks to it's precision and strenght to pry open most of the plastic parts. The triangle end is sharp enough to enter the most thin openings. At the same time, the shovel end is able to apply great force without damaging the plastic thanks to it's thickness and rounded eadges.

3. Heavy spudger

In order to be able to pry open plastic cases with multiple snap fits we need more than one spudger. The flathead screwdriver is a favorite in the repair community and the second best scoring prying tool in the tool validation test. Nevertheless, we need to design our own heavy spudger in order to fit all the requirements ditacted by the different gestures the users have to carry out.

4. Front brush

According to the tool validation test, a long brush is the best way to access the coffee grounds that are hard to reach with a wipe.

5. Solid extender

The amount of hard to reach screws within bean-to-cup machines calls for a bit extender that is precise and stable enough to reach all the internal parts of the coffee makers. All the participants in the tool validation research agreed that this tool is needed, so we need to develoup a solid extender that satisfies those needs.

6. Cylindrical brush

While the cylindrical brush was not used during the tool validation research, the videos used in the product based research show that in order to clean clogged nozzles and tubes, a long and soft cylindrical brush is necessary.

7. Heavy spudger

While most maintenance products like cleaning tables and water filters are beeing sold by the coffee maker brands themselves, non of the analyzed brands in the product based research sell their own food grade lubrication. This product is an essential part of the monthly maintenance routine. With the reputation of iFixit, there is an oportunity to provide a lubricant which consumers can use during maintenance.

8. Tweezers

Ocasionally screws can fall during dissassemling and re-assembling in difficult to acces spaces, and picking them up can be a challange. Tweezers can offer assistance in those situations but they are not essential for coffee maker repair.

MOST RELEVANT

① 0 1 2 3 4

T8H T9H T10H T15H T20H T25H

1 2 3 4 Oval

② 

③ 

Exact tool needs to be found or designed.

④ 

Exact tool needs to be found or designed.

⑤ 

Exact tool needs to be found or designed.

⑥ 

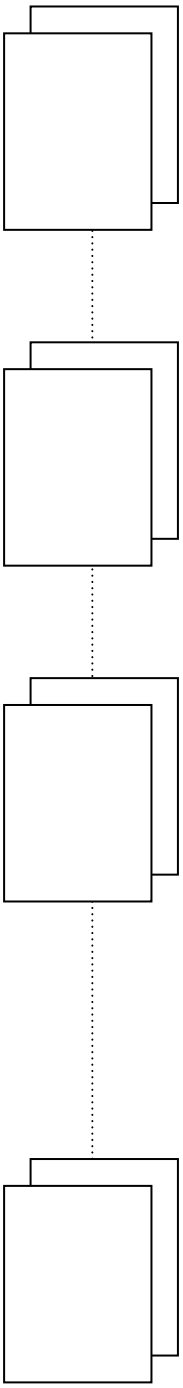
Exact tool needs to be found or designed.

⑦ 

⑧ 

LESS RELEVANT

Ideation



Tools
Tool selection & design
Spudger & extender test

Toolbox
Testing current iFixit toolbox
Toolbox design
Testing toolbox design

Fault diagnosis website
Decision-tree for fault diagnosis
Website interface
Test Nº1 of the website
Test Nº2 of the website

Final Deliveries
Website for fault diagnosis
Toolkit (toolbox + tool selection)

2.1 Approach

The research phase has enabled us to understand the requirements from the machines and the need from the people that repair them. In the following section we will translate those requirements and needs into physical products (toolkit) and a digital product (website). From the toolkit point of view we already have defined the fundamental tools that we need to include, now it’s a matter of selecting and testing the tools that are not available in the current iFixit portfolio. The testing will define if the new tools actually add value to the repair explirence. The objective is come up with a toolkit inlcuding the fundamental tools from the priority grap, which will be all except for the tweezers.

From the user research we’ve learned the importance of fault diagnosis for those who lack experience in repair (i.e. newcomers), and during the Mid-Term discussion it was decided that this would be a field where we can bring something of value. So for the digital product, we are going to develop a website which assists the newcomers in finding out what is wrong with their coffee maker.

In the following section we will explain what process we have followed to design and test the different elements of the project: the tools, the toolbox and the website. The testing will be done with friends and colleagues since the participant recruitment during the user research section has proven that finding coffee maker owners in times of COVID-19 is very challenging.

2.2 Tools

2.2.1 TOOL SELECTION & DESIGN

Intro

The research has enabled us to come up with a selection of tools and their priority for the repair and maintenance of coffee makers. Some of those tools are currently not available in the iFixit portfolio, so we need to incorporate them by either outsourcing them from other manufacturers or developing a new tool if outsourcing is not possible. In this section we are going to explain the selection and design criteria of the rigid bit extender, cylindrical brush, frontal brush and the heavy spudger. Thanks to the insights of the tool validation, we can start with a list of requirements for these tools, which will help us select the best available tools during the market research. If none of the currently available options fulfills all the needs that we detected, we will design and develop our own tool in order to address all the listed requirements.

In this section we will not select a specific food-grade lubricant since we don't have the resources to compare the quality of different lubricants in order to choose the best. Nevertheless, food-grade lubricant is an essential part of the maintenance process, and ensures the proper working of the coffee maker, so it has to be included in the toolkit. Additionally, there aren't many coffee maker brands offering their own branded lubricant, so there is an opportunity for iFixit to include their own food-grade lubricant.

Tool requirements

Rigid 4mm bit extender

In order to access the screws that are hard to reach using only the iFixit Precision Bit Driver, we will need a rigid 4mm extender. The tool validation section showed us that the current flexible extender is not the most adequate tool; It's hard to insert the bit inside the screw head since it wobbles and the extender deforms when we have to unscrew a very tight screw. Therefore the selected extender needs to be rigid, this will allow for more precision when inserting the bit and a better resistance to torque force. The minimum length of the extender should be of 90mm, but this is entirely based on the testing of one machine, the Jura ENA 7, and may not be sufficient for other models. The participants also mentioned the desire for a magnetic tip, so that it's easier to insert the bits and the screws don't fall during the re-assembly process. Additionally, since some screws are located at the bottom of very narrow holes, the width of the extender should be as small as possible. But again, since we just have the Jura ENA7 at our disposal, we don't know how small the width of the extender has to be for other coffee maker models.

Heavy spudger

Some coffee machine cases require a lot of prying force in order to open them up. In those cases the current iFixit metal spudger doesn't offer an ergonomic grip and even bends under a large load, which consumers fear means that the tool will break. For those extreme cases we need a spudger that offers a good grip handle (similar to the handle of a flathead screwdriver) to comfortably apply level force and torque force. Additionally, the heavy spudger should be thick enough to prevent any bending. Since we are talking about a scenario in which large forces are going to be applied onto plastic parts, so the blade of the spudger should be rounded and soft enough to prevent any kind of possible damage.

Frontal brush

The frontal brush needs to have a long handle to reach the deep part of the coffee maker and soft brush hair in order to clean the delicate parts. In this case, finding an adequate option should be easier, since there are a wide variety of "espresso brushes" that are especially designed for coffee makers. The total lenght of this tool should not be much greater that the iFixit metal spudger, which is the longest tools from the current selection. This lengh restriction influences the final size of the toolkit, which we want to keep as small as possible.

Cylindrical brush

The cylindrical brush should be thin enough to clean the internal flow tubes of the coffee machines. The wire handle needs to be as long as possible since the internal tubes can be quit deep, but it's important to remember that we don't have exact data on the lenght of the tubes of each model. As in the case of the frontal brush, there are cylindrical brushes especially made for coffee machines, so the final lengh will be determined by the most adequate cylindrical brush we can find in the current market.

Market research

Rigid 4mm bit extender

During the search for a 4mm bit extender we only considered tools that came from reputable brands and manufacturers. In order to avoid any risk, we excluded unknown manufacturers and brands from which we couldn't verify the quality of the product or their reputation. The "System 4 Magnetic Extension Blade" from Wiha tools is the most appropriate option since it complies with all the listed requirements and comes from a trustworthy brand. Another available option would be the 123mm extender from FIXFANS, but the width is bigger than the Whia extender and the manufacturer's trustworthiness couldn't be evaluated. Other extender alternatives where not available in the 4mm bit size or came from untrustworthy manufacturers.

Fig. 0. Wiha "System 4 Magetic extension blade

Heavy spudger

We found no commercially available spudger that complied with our requirements. Spudgers with plastic handles such as the Kaisi metal spudgers have a blade on both ends, not providing a comfortable surface for the hand when trying to apply torque force. The closest tool for our requirements would be the ABN Bike Tire Lever set, but the length of this tool is of 290mm and the curved blade makes it inadequate to apply torque force while prying. From this lack of proper options we conclude that we need to develop our own tool in order to cover all the listed requirements.

Fig. 0. Kaisi metal spudger

Fig. 0. ABN Bike Tire Lever set

Frontal brush

The best commercially available brush is the “Espresso brush 751114” from german manufacturer REDECKER. With it’s soft hair and total length of 209mm it’s ideal to clean off coffee ground and residue while having an adequate lenght. Nevertheless it’s high quality probably makes it one of the most expensive options. Another alternative is the Joe Frex cleaning brush, but it’s total lengh is of 230mm. If both these options end up being too expensive for the final product, iFixit needs to look for producers of similar brushes from cheaper manufacturers. The final front brush needs to have soft brush hair and a length that ranges from 180mm to 200mm in order to fit within the toolkit dimensions.

Fig. 0. Espresso brush from REDECKER

Fig. 0. Joe Frew cleaning brush

Cylindrical brush

As with the frontal brush, there are a variety of different manufacturers offering coffee maker specific cylindrical brushes. One option that fits our requirements is the “Cleaning Brush for Milk Hose and Tubes” from ECCELLENTE, a dutch shop. This brush is 190mm long and is especially made to clean coffee maker tubes.

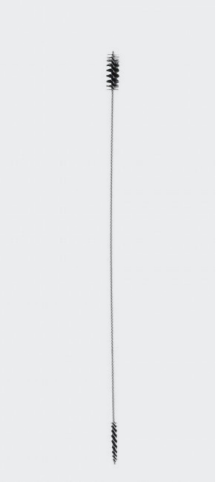


Fig. 0. ECCELLENTE Cleaning brush

Design of heavy spudger

We have found good picks for the bit extender, frontal brush and cylindrical brush, but we need to develop a new heavy spudger in order to comply with all the requirements. The design of the heavy spudger should be as similar as possible to current available spudgers, so that the consumers understand what it's purpuse is when they see it.

The total length of the tool is going to be 200mm, 20mm more than the iFixit metal spudger. The spudger blade is going to be 10mm wide, with no curvature for better torque and rounded edges to protect the plastic parts. The stem is going to be ø5mm in diameter to prevent bending under large prying forces, yet to validate this dimension we should carry out a bending moment simulation before it goes into production. The handle should have large grooves for easier grip, avoiding small groves where dirt and coffee residue are hard to remove. The handle is going to be 110mm in lenght and ø26mm in diameter, which fits into the recommended range to allow for a power grip on the tool accoridng to the Principles of Hand Tool Selection (2004). Finally the edge of the handle should be rounded to provide a better contact with the palm of the hand.

All these design parameters were translated into a metal and wood prototype to check for the general dimensions. After that, we 3d printed the handle and inserted a commercially available metal blade with rounded edges. This final prototype enabled us to see if we could comfortably apply lever and torque force in order to pry open though plastic cases, like the Nespresso Pixie case.

Fig. 0. Design of the heavy spudger

Fig. 0. Heavy spudger prototype

Conclusion & Next steps

The insights for selection and design were extracted from the product based research and the tool validation. It's important to remember that the tool validation was done with only two coffee maker models, so some precise requirements like the length of the extender tool or frontal brush are just validated for one bean-to-cup machine and one capsule machine. Nevertheless, in the product based research, we saw that the construction and size of bean-to-cup machines is quite similar amongst different models and brands. If more precise validation is required to check the features of these tools, then we need to test them with models from different brands listed in the product based research section.

The next step is to test if these new tools bring value to the user using the coffee makers we have at hand. Since the selected frontal and cylindrical brushes have been specifically manufactured for coffee makers, we will not test them in the next chapter. However, the heavy spudger and bit extender have not been made specifically for this context, so we need to validate if they work properly in this scenario and if they bring value to the participants during test.

2.2.2 SPUDGER & EXTENDER TEST

Intro

Since the heavy spudger and the Wiha bit extender are new additions into the tool list (that are not especially designed for coffee makers), we need to test them with participants to see if they improve the repair experience. Both these tools are used in different scenarios so the evaluation method will vary for each one. For the bit extender we are going to compare it with the original iFixit flexible extender in the same repair scenario, and see if the new Wiha extender makes a difference in the participant's satisfaction. Therefore, the first research question will be: Do the participants prefer the Wiha 4mm bit extender over the iFixit flexible extender when used in the same scenario?. For the heavy spudger we are not going to compare it with another spudger, but rather see if its inclusion is necessary or if participants have enough with just the current iFixit metal spudger. The research question for the heavy spudger will be: Do the participants need the heavy spudger when prying open though plastic cases or do they have enough with the current iFixit metal spudger?.

Fig. 0. iFixit Flexible extender and Whia extender

Fig. 0. iFixit metal spudger and heavy spudger prototype

Method

The participants of this process were 2 males and 2 females. Two of those participants already participated in the tool validation research and were familiar with the repair scenario. The test was carried out on a 800×1600mm table, where they had the coffee machine, the necessary tools and a laptop with the repair guide.

The first part of the test consists of disassembling and reassembling the brew unit of the Jura ENA7. For this process the participants have to use both the solid extender and the fixit flexible extender to loosen (and later thingten back) the two screws that hold the brewing unit in place. This process allows us to compare the two tools to carry out the same repair process.

For the heavy spudger we asked the participants to remove the necessary plastic parts of the Nespresso Pixie in order to access the main electronic connections. This process requires spudgers for both delicate prying and forceful prying. For this task they could use the shovel-triangle iFixit spudger and the heavy spudger at the same time. As mentioned before, this would allow us to see if the heavy spudger can help in situations where the iFixit metal spudger is not enough.

Since the number of participants is so low (due to the COVID-19 situation) we are going to evaluate the results in a qualitative manner, analyzing the comments and opinions of the participants to answer the research questions.

Fig. 0. Wiha extender during the test

Fig. 0. Heavy spudger prototype during the test

Results

The test results confirmed our insights from the tool validation regarding the need of a solid extender. The Wiha magnetic extender was preferred by all 4 of the participants. “It’s easier to insert it into the screw head since it doesn’t wobble so much [...]” and “With the metal extender I can actually feel if the screw is turning or not” are comments that the participants expressed during their expirience with the Wiha 4mm extender. Overall, the ability to be more precise, the greater feedback from the screws thighness and the ease of the magnetic bit holder were the main pros of the rigid extender. The wiggles of the flexible extender become even more clear when switching to the Wiha extender.

The second test showed that when the prying requires a great deal of force, the heavy spudger is appreciated, but the participants are still reluctant to use it. “I need two tools in order to open up the case, but for the rest I will stick to this tool [iFixit spudger] since it’s more gentle [...]” and “The screwdriver tool [heavy spudger] is easier to grab but it looks very aggressive [...]” are examples of this perception. The heavy spudger was necessary when opening the outer case of the Nespresso Pixie, but since this requires a great deal of force, the participants fear it will damage the plastic parts of the coffee maker. Yet the moment the iFixit metal spudger starts to bend or they can’t find a good way to grab it, they switch to the heavy spudger.

Fig. 0. Heavy spudger prototype during the test

Conclusion & Next steps

With the Wiha extender it's clear that it's inclusion will provide a lot of value to the toolkit, even though it's still not proven if it's 100mm length is enough to reach the embedded screws from all the bean-to-cup machines, since we just have the Jura ENA 7 at our disposal for testing.

For the prying we have learned that the iFixit metal spudger is the most preferred choice (as also seen in the Tool Validation research), but that when more thought prying is required, the availability of the heavy spudger is appreciated to apply more force in a comfortable way. It's important to take into account the aggressive perception of the heavy spudger, which makes participants reluctant to it's use. The question arises if the design needs to be more approachable and how we can reduce the fear of damaging the plastic parts. There is the option of covering the spudger blade with a plastic coating, reducing the chances of scratches, but this needs further testing with manufactured prototypes which we can't obtain in this project.

2.3 Toolbox

2.3.1 TESTING CURRENT IFIXIT TOOLBOX

Intro

So far we've looked into the selection and design of individual tools. In this section we are going to look into the experience with the storage and presentation of the tools themselves, looking into the current iFixit toolbox and what we can improve to enhance the user experience. This will allow us to come up with design improvements for our own toolbox design. Hence the research question is the following: Which features of the current iFixit toolbox design do they appreciate and what can we change in order to improve it?

Method

To get insights into possible design changes we are going to make 5 participants (3 female & 2 male) use the iFixit Pro Tech toolkit to disassemble the boiler cover from a coffee machine, two of those participants already took part in previous tests. For this process they have to use multiple screw bits, the bit extender and the driver to access the boiler cover. This test will be carried out in the same context as the heavy spudger and extender test: On a 1600×800mm table where they will have the coffee maker, iFixit toolkit and a laptop with repair instructions.

After the disassembly and reassembly process, we are going to ask them about the features of the toolkit they like and the ones they would like to change, gathering their observations as qualitative data. The objective is to get an overview on how the different details of the toolbox influence the experience from the participant's point of view.

Results

Regarding the features they would like to improve, the two most mentioned problems are the lack of contrast in the screw bit icons and the lack of a "groove" to ease in opening the box; "It's hard to open up the cover with one hand" and "I can't see the sizes of the screws clearly [...] I don't know if I put it in the right place" are two observations regarding this matter. For the first one, when it comes to the process of opening the toolbox, the magnets and the lack of a proper gripping surface difficult this task, especially if the participant has just one hand available. Regarding the second comment, the laser printed icons on the foam are too small and too low in contract to distinguish them one from another. For beginners who don't know all the shapes and names of the screw heads, this presents an issue if the quantity of bits is so large.

On the other hand, the participants really appreciated the soft foam surface that holds all the tools in place and the magnetic cover. The foam surface has enough grip for the tools to stay in place while at the same time allowing a soft insertion and extraction, especially when compared to hard plastic clips, as one of the participants mentioned. The magnetic cover allows the users the freedom to put it wherever they want if the space is limited.

One participant (who also took part in a previous test) made the observation that "The squares from the back of the cover are useful to store the screws, because if I place them in the table they just roll away [...]". There is an opportunity to use the cover nerves, which are originally just meant to provide stability, as a storage area to organize the screws from the coffee machine. This would especially benefit in repair processes where with a large number and variety of screws.

Conclusions & Next steps

A lot of the features from the current iFixit toolbox were appreciated by the participants and should still prevail in the coffee maker toolkit. The magnetic cover, the soft foam material and the nerves of the cover add advantages to the experience when compared to other designs of toolboxes. Regarding the cover nerves, we can use this already existing feature for our advantage, but it will only work with smaller screws and fixing elements.

The only aspects we need to re-design, according to this analysis, are the visibility of the icons and the shape of the cover to make the opening more accessible.

Add a groove to ease the opening.

Higher contrast on iconographty.

Promote the use of the cover nerves for the organization of the screws.

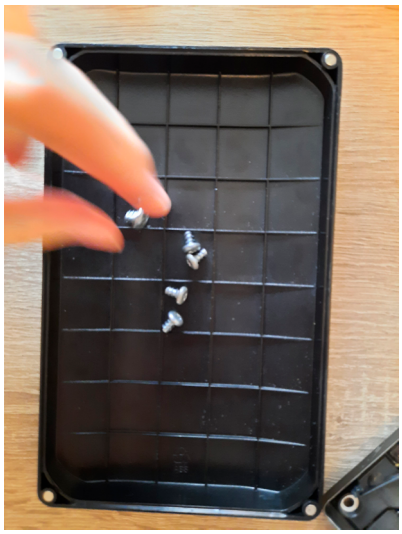


Fig. 0. Using cover nerves as organization space

Fig. 0. Difficulty to open the case with one hand

2.3.2 TOOLBOX DESIGN

Intro

Now that we have insights into how people navigate the maintenance and repair of their coffee makers, what tools we have to include and what we can improve upon the current toolbox design, we are going to design the toolkit in order to improve the repair & maintenance experience as a whole. The goal is to come up with a design that fits into the iFixit brand and addresses the requirements we have detected until now. Due to the lack of time and resources this design will only be prototyped once. Nevertheless, after this section we are going to test this toolkit design (toolbox + selected tools) one more time with participants. This will allow us to get further insight into what we have improved and what still needs to be addressed.

First we are going to state the requirements the design needs to satisfy, so we can later verify if the design is successful. Then we are going to talk about the design prior to the final testing. The final design (post “Testing toolbox design”) will be addressed in the final section of this report called “Final product”.

Requirements

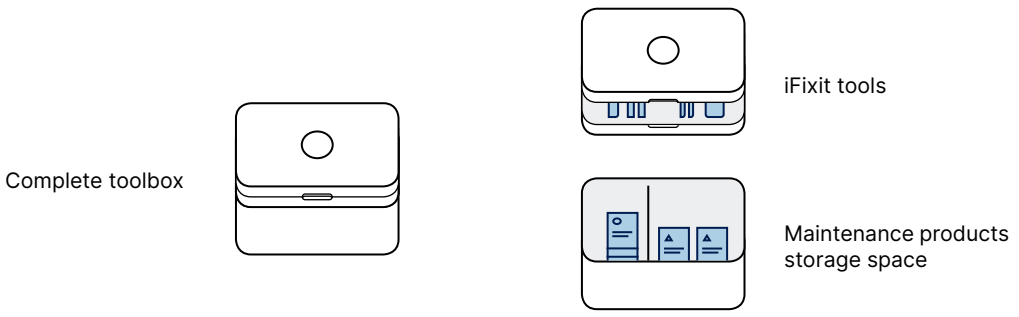
The first requirement, as mentioned in the introduction of this section, is that the design fits into the branding and aesthetics of iFixit as much as possible, while leaving room for the necessary design changes. Since we saw that the maintenance of coffee makers requires both the selected tools and the cleaning products from the specific coffee maker brand (e.g. cleaning tablets, water filters, descaling agent, etc.), the goal is to incorporate all the necessary products into one single toolbox. This means that the consumers can reach into this toolkit no matter the technical problem they are trying to fix with their machine. At the same time, it’s important to consider that some consumers may only be interested in purchasing the tools, since they already have a designated space for the specific coffee model products. As a consequence, we should be able to offer just the iFixit tools independently, without having to design a completely different product for this case. The coffee maker toolkit will be used in a different context than most toolkits; The kitchen. This means that the toolbox design needs to adapt and fit in context both functionally and visually. Thereof we need easy to clean materials that are resistant to water and dirt, avoiding the use of textile like in the iFixit Tech Pro toolkit.

Design

The structure of the toolbox is very similar to the current iFixit toolboxes, with the exception of it's bigger overall size and the bigger corner curves to fit better the kitchen aesthetics. The toolbox is divided into two sections; the iFixit tools and the storage section for the single use maintenance products. The selected tools include all the listed tools we have tested until now, with the exception of the tweezers. These tools are stored in a cutout foam with the icons for each screw bit type. The storage space is an open area, so that products from all sizes and brands can fit. The walls include rails to allow for dividers, in case the consumer wants to organize the storage space into different modules.

This structure allows us to sell the ifixit tools individually or the two sections together, without needing a separate design for each case. The two sections are held together by magnets, in the same way as the current iFixit tool boxes. The toolbox design also incorporates the design changes detected in the toolbox test; a groove has been added to easily open the box with one hand, the screw bit icons have a higher contrast with the foam and the cover nerves have numbered squares to order the screws during the disassembly.

Since we incorporate tools like the heavy spudger, metal spudger and front brush (which are all around 200mm long), the toolbox is 230mm in width and 230mm in depth in order to fit all the selected tools. The height of the toolbox is 140mm leaving a large space for coffee maker specific maintenance products like cleaning tablets, water filters, descaling agents, replacement parts and so on. This large space comes with a consequence, the overall toolbox is going to be very large when compared to other toolboxes from iFixit.




jura
3×3
jura
SPACE
SCREW


DKS
IFIXIT

Conclusion & Next steps

As mentioned in the requirements, the philosophy behind the design process of the toolbox was to stay as close as possible to the iFixit branding and current toolbox design. This has led to a design that, while addressing the needs we detected, is not very innovative or distinct from what we currently see in the market. Nevertheless, by expanding on the current iFixit design, this allows us to validate the new design details more more in depth, instead of having to evaluate a completely new design. With the time and resources we have for this project, this was the most appropriate approach to get realistic outcomes.

The next and final step in the toolkit (toolbox + tools) design is to test how the participants interact with the tools and the toolbox together, joining the two to validate their impact on the maintenance and repair experience.

There are two aspects which we will not be able to address in this project: How the size of the toolbox affects how consumers will store it in the kitchen and how many consumers would prefer to buy only tool section rather than the whole toolkit. To get accurate information about these issues we would need large amounts of data that we cannot gather with the available resources.

2.3.3 TESTING TOOLBOX DESIGN

Introduction

With the tools already validated, now it's time to put them in the new toolbox and see how participants interact with them. The goal of this test is to see if the design changes that we made are understood and appreciated by the participants. The research question addressed in this study will be: Do the participants find the new features useful?. We will ask them to carry out a full maintenance cycle in order to allow them to interact with the toolkit multiple times. The maintenance cycle is also the most common thing the consumers are going to use the toolkit for, so we will test the most habitual interactions. It's important to mention that, like in the other test, the insights are going to be based on one coffee maker model, the Jura ENA7. For this model the maintenance cycle includes: Cleaning the brew unit, empting the dump and drip tray, filling the water tank and cleaning the flow system with a cleaning tablet.

Method

This test is going to be carried out with 5 participants from which only one has participated in previous tests. The participants will have available the new toolkit, the coffee maker and a laptop with the repair maintenance instruction, all laid out on a 800×1600mm table with the necessary lighting. They will be given the toolkit without any explanation of what they have to use or how to use it, but they can ask questions about the maintenance instructions if they have doubts (since this is not part of the test). The participants also won't know that the test is about the toolkit itself until the end of the study. In this way we can observe how they interact with it without any previous bias or expectations. After carrying out the maintenance process they will be asked why they did or didn't use certain features. The goal is to get qualitative information on how the new features influence each interaction with the toolkit.

Fig. 0. Coffee maker and toolkit

Fig. 0. Participant using the screw organizer

Results

The participants were able to interact with the toolbox without major problems or obstacles that dificultad the maintenance process. All participants used the groove in order to open up the toolbox cover, no one tried to open it via other possible methods like lifting the cover by grabbing it by the sides. The groove was quickly noticed by the participants since there aren't any other distracting visual elements around the toolbox. When asked about it, one of the participants mentioned "I didn't even think about it, it reminds me of the gap my macbook has to fold the screen open, so I just went for it [...]". When it comes to the cover squares to organize the screws, 3 of the 5 participants used it. One of the participants that didn't use it mentioned "I saw it when I first opened the box, but during the disassembly I didn't have many screws, so I just left them on the table near the coffee machine". The icon of the screw bits helped during the search of specific bit types, like the oval tool, which is easy to distinguish from the rest of icons. When they finished the reassembly process, they all put the bits back into the right place, confirming that they understand the icons for each screw type. None of the participants had trouble finding the cleaning tablet in the storage section, but one of them needed to fiddle around with the toolbox for a while until he discovered that it was attached via magnets.

The only problem all of them pointed out was the strength of the magnets, which were too strong for them. One participant mentioned "I'm afraid it will snap my fingers when I close it [...]". Another thing they noticed is that the toolbox takes up quite some space due to its big size, but in this test, since the table was big enough, it didn't present a problem during the maintenance process.

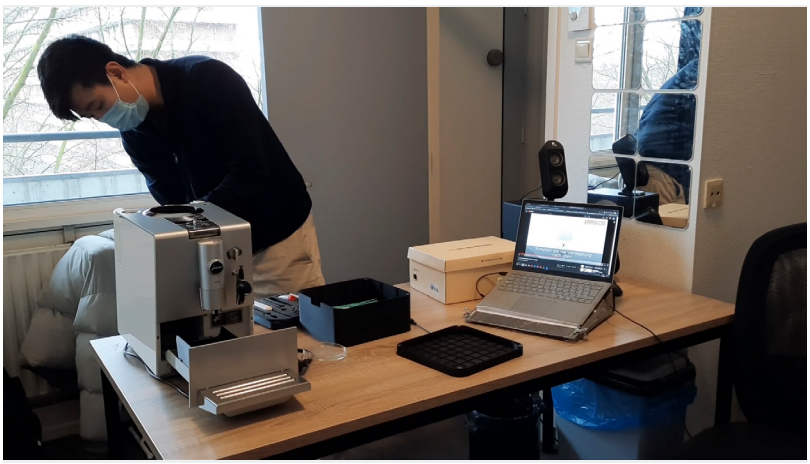


Fig. 0. Testing setup

Conclusion & Next steps

The participants understood how the toolbox worked and were able to complete the whole maintenance cycle without major problems. This has allowed us to see how features like the groove and the screw organizing space were used as intended, and changes like the increase in icon contrast seem to have improved the situation, while the later one is harder to justify solely based on this test. Considering that it's the first time they had interacted with this prototype, they were quick to comprehend how the tools were divided and how to access each section. The only problem they all agreed needed fixing was the magnet strength. This means that we will need to implement smaller or weaker magnets than the N24 ø8mmx3mm magnets that were used in this prototype.

The only aspect which is up for discussion after this test is the size of the toolbox. This test was carried out in a 800×1600mm table where they had enough space to operate, but the question arises of what would happen they used it in a smaller kitchen with less space.

It's difficult to reduce the width and depth of the toolbox since this dimension is dictated by the amount of tools and their size, but we can reduce the height of the overall toolbox. By reducing the height of the storage section we will provide less freedom to store more products, but we can significantly decrease the overall size of the toolkit. If consumers just have the basic recommended maintenance products (i.e. cleaning tablets, descaling tablets and water filter replacement), we can reduce the height of the storage section to 40mm.

2.2 Website

2.2.1 DECISION-TREE FOR FAULT DIAGNOSIS

Intro

We know that, for the newcomer, finding relevant information during the initial online search (before deciding to get into the repair) plays a big role in setting expectations and foreseeing possible frustrations that could occur. Having accurate knowledge on what the fault could be provides a sense of direction and security, making the repair process smoother and less intimidating.

In response to that, we are going to develop a website with the goal of “Assisting the user through the fault diagnosis process by associating the perceived symptoms to a specific cause.” The website should evaluate the different symptoms the user perceives and come up with a cause or a narrow number of causes responsible for the fault. In order to structure this interaction between user and website in a familiar way, the communication is going to be done via questions and answers, similar to what happens in repair forums. In this way we mimic an information exchange that is already familiar. The user should just input the perceived symptoms and follow the instructions displayed, without needing to understand the internal workings of the coffee machine.

The core of this website is going to be the decision-tree that leads us to a specific cause once we answer the questions regarding what symptoms we perceive. This section is going to address how we developed the decision tree based on already available information about troubleshooting and online guides.

Method

A failure mode analysis consists of checking the state of multiple components and subsystems within a product or mechanism in order to identify what specific elements are responsible for the fault (Rausand & Hoylan, 2004). For this we need a list of all the possible causes of failures and how they manifest in symptoms that the consumers can perceive. Once we redact the questions about each specific symptom, the user will just need to read them, check if they appear on their coffee maker and answer according to what they perceive. With each answer the number of possible causes is reduced, since each question asked addresses one of the possible causes.

In order to build the decision tree we need information on how each symptom relates to a cause in a bean-to-cup machine. Even though we also focused on capsule machines in the tool research, for the decision tree we are going to focus exclusively on bean-to-cup machines. This will allow us to give directions based on the specific elements and structures of these products, rather than making a very general decision tree for all types of coffee makers, which would lack a lot of depth. By combining the information of troubleshooting guides from different bean-to-cup models (Jura ENA8, Siemens EQ.6, De'Longhi PrimmaDonna), coffee specific websites (Mr. Bean2Cup & The Espresso Shop) and general repair books (How to Fix Everything For Dummies) we can come up with eight possible elements that are responsible for the fault (as seen in the results).

The same sources also name different symptoms associated with each cause. So by combining those symptoms and organizing them by how easy they are to check and/or their probability of occurrence, we can come up with a model that starts from common causes to more rare issues. You can find this decision tree in high resolution in in the next pages. The first question in the decision tree is regarding the main symptom i.e. how they noticed the machine stopped working property. Since there are a large number of main symptoms, we need to categorize them into different fields. In this first iteration they have been divided them into symptoms related to the coffee/water output, coffee maker behaviour and other issues. In the testing phase we will need to verify if the users understand those categories and if the large numbers of options (12 main symptoms) cause confusion in this first part.

Apart from questions and answers the decision tree also will include instructions on how to solve the problem or on how to get more insight. Those instructions are going to be related to one of the eight causes that we detected. This means that if eventually the fault diagnosis is not successful at the end of the process, at least we know which causes we can discard since we already addressed them.

Results

Possible elements that can cause the fault:

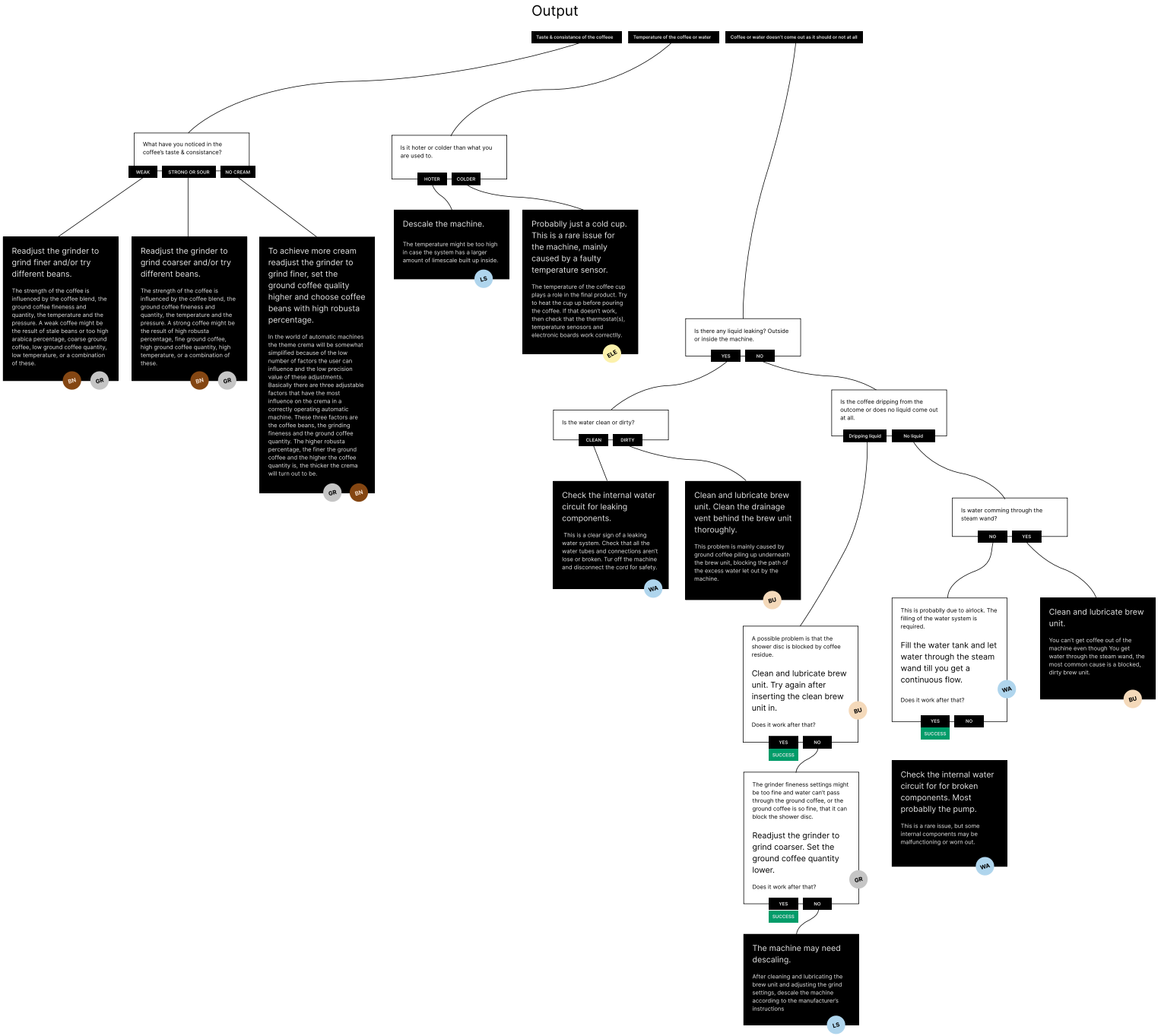
BU	Brew unit related	FS	Internal flow system
EE	Electrical/Electronic components related	LS	Limescale related
GR	Grinder related	FR	Frother related
BN	Coffee bean type related	WS	Waste (Dump box & Drip tray)

List of main symptoms

GROUP	MAIN SYMPTOMS
Outcome	Taste & consistance of the coffeee Temperature of the coffee or water Coffee or water doen't come out as it should or not at all
Product behaviour	An error message is displayed on my machine A light symbol/icon is displayed on my machine Brew unit does not function correctlly Grinder does not function correctlly Steamer/Frother does not function correctlly Coffee machine won't turn on at all
Other	Waste related (coffee grounds & liquid) Unusual noises Unsusual smell

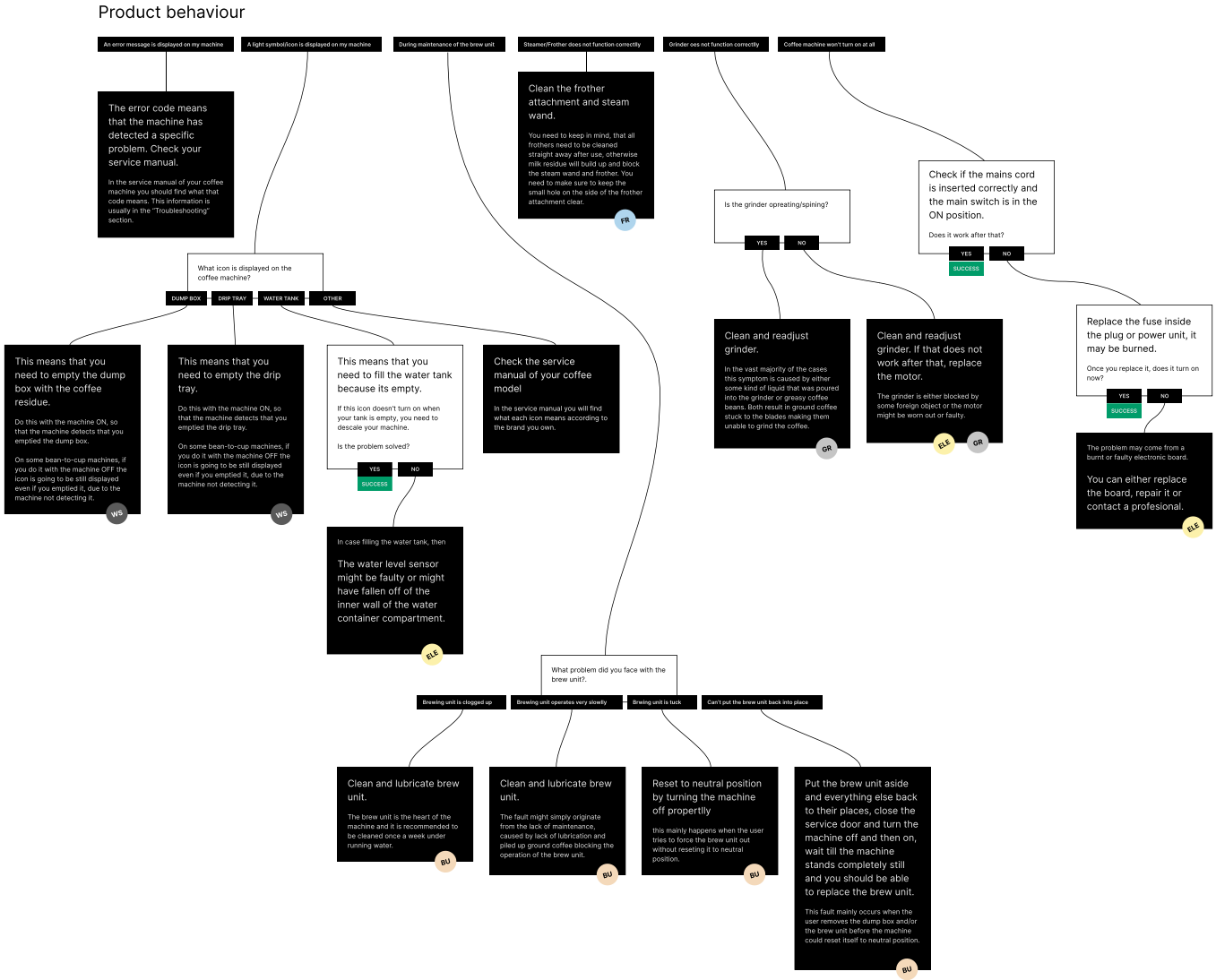
“Output” section of the decision tree

Print in A3



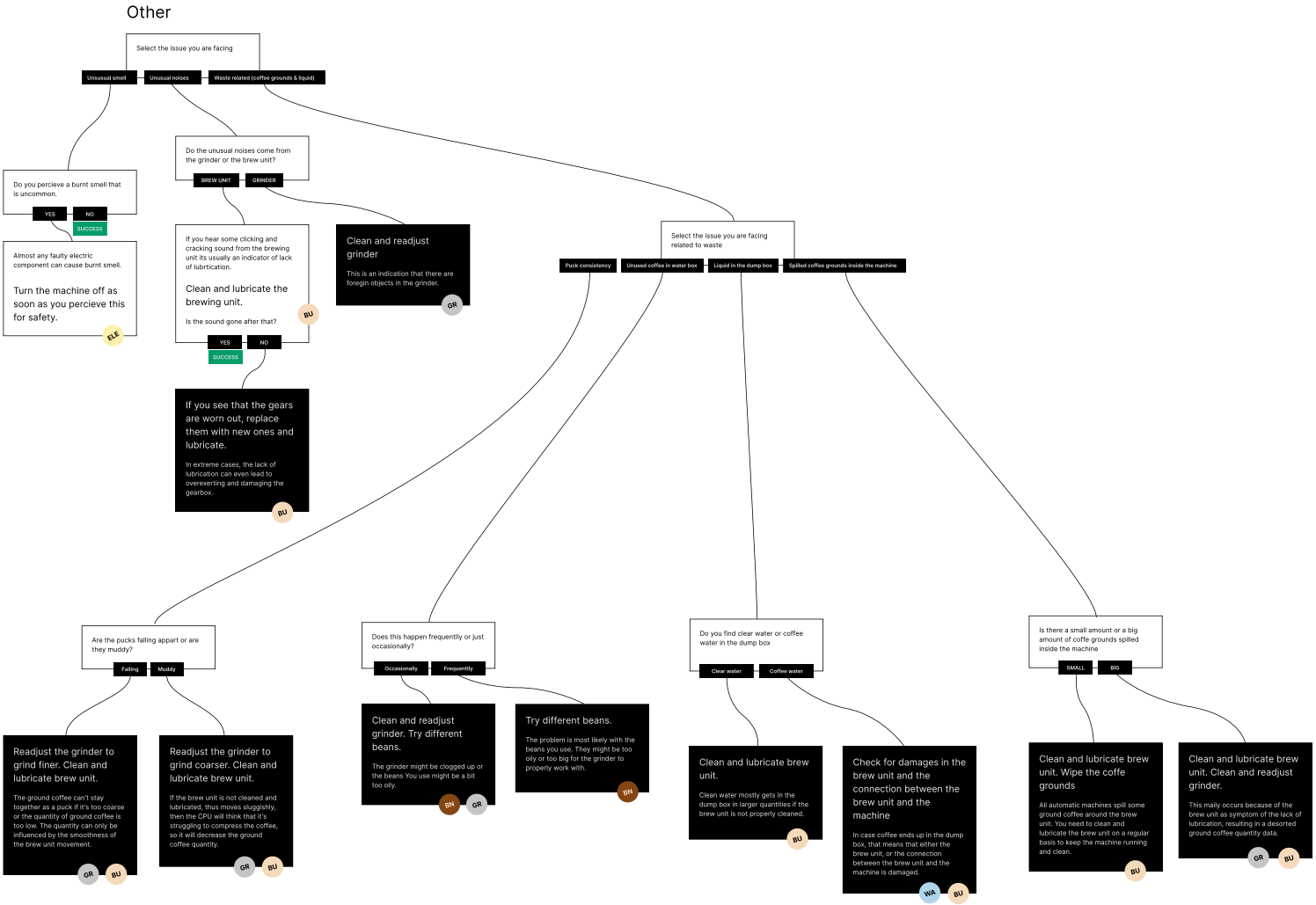
“Product behaviour” section of the decision tree

Print in A3



“Other” section of the decision tree

Print in A3



Conclusions & Next steps

We can’t test if this decision tree works for every bean-to-cup machine available due to the lack of budget and resources, but for future developments it would be useful to carry out a test with at least one model per brand, to see if the decision tree is broad enough to tackle different types of mechanism and designs. Another thing that needs to be validated is the consumer’s comprehension of the questions and the possible answers. The tests we are going to carry out for the website are going to be done via video call with participants who don’t own a bean-to-cup machine, so we can’t evaluate if they can relate the questions to the perceived symptoms in real life. Nevertheless, for the testing we are going to develop the full tree for the “Coffee or water doesn’t come out as it should or not at all” option, and that could give us some insight into how they see the questions as they are currently written.

2.2.1 WEBSITE INTERFACE

Intro

Now that we have the decision-tree that's going to serve as the backend system of the website, we will design the website UI in order to make the navigation easier. While the decision-tree can be used by just following the graph, it can be complicated to read for newcomers, who may be pushed away by the large number of paths and visual information. Thereof, we need an easier way to communicate the same information by steps, rather than the full picture at once. A digital UI is the perfect way to present the same decision making process in an accesible manner for those with less experience.

Method

The process should start with the user understanding what he is interacting with, since this interface will feel novel and unfamiliar. A welcoming page should be able to shortly state what the website can do for the user. Once the users get into it, they need to select the main symptom from a list.

After that initial set up, the user will need to answer a series of questions in order to figure out what the specific cause could be. In the best case scenario the question is enough for the user to understand what he/she has to answer in a short span. In the case the question is not enough we should provide additional information to clear out what is ment. Additionally, in order to allow the community to participate and to provide more perspectives on the question, we can incorporate comments for each question, so people can help each other out about the uncertainties.

The number of possible answers should be reduced to 5 in order to avoid overstimulation (Halarewich, 2016). If the questions requires more options, then the fifth option should be "Other..." and lead to a new question page. Additionally the answers should be ordered by major probability to minor probability for easier readability.

The question process should start with the symptoms you can detect without needing to tear down the coffee maker. If the user needs to disassemble the coffee machine, then we need to link the right tools and tutorials. This is also a good opportunity to link a disassembly video and advertise the physical toolkit we are developing.

It's important to indicate what part of the process the user finds himself in, and enable him to backtrack if he accidentally answers a question wrong. For the same reason, there needs to be a way of going back to the home screen if they want to start again from zero. If the process is successful then the user gets a congratulation screen and the case is stored. If the guide is incomplete and there is no answer available then the interface shows a range of possible causes and the causes are not responsible for the fault according to the answers given.

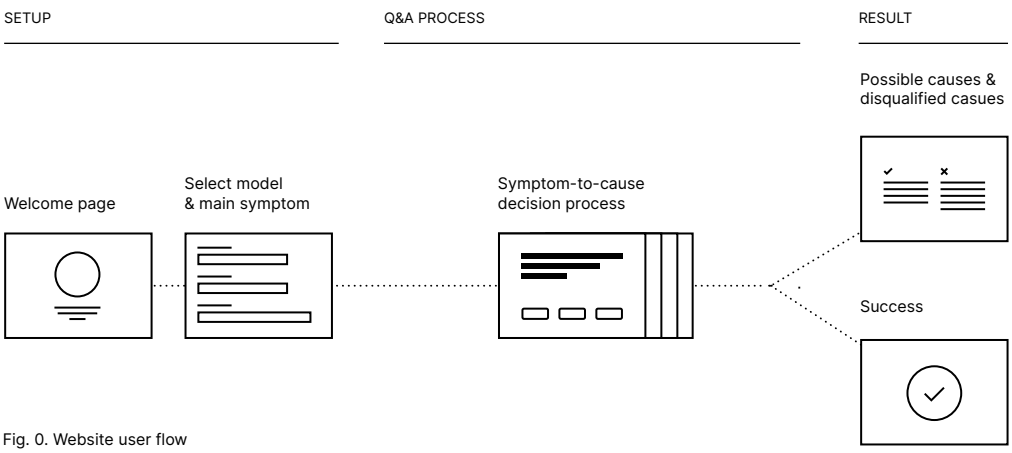
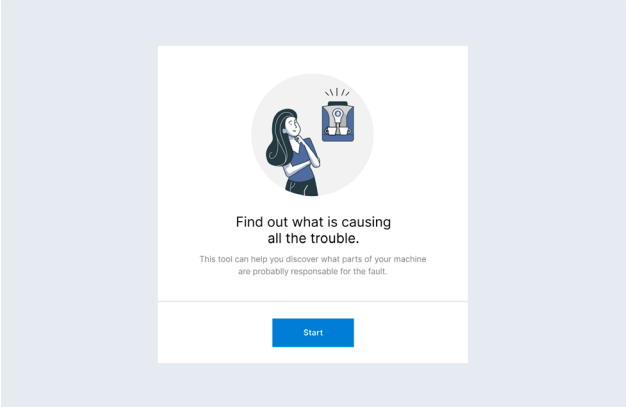
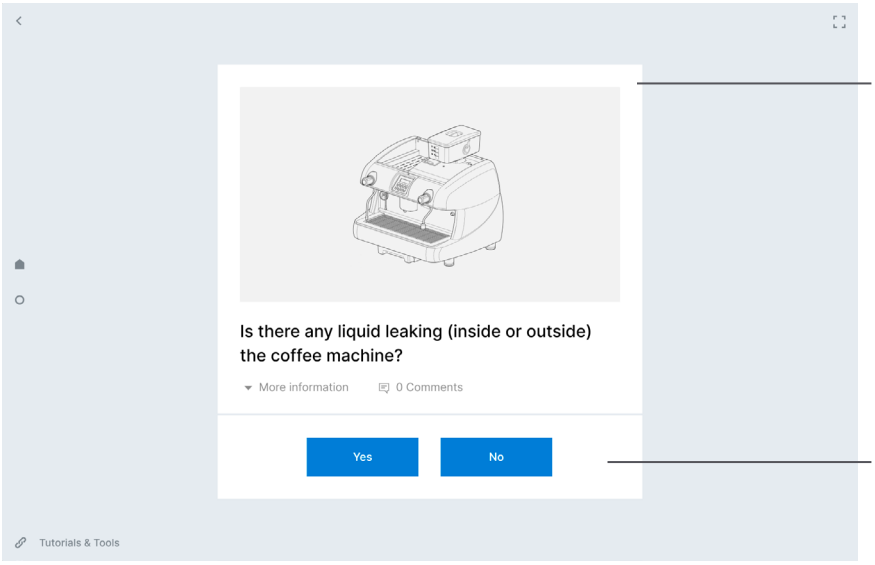


Fig. 0. Website user flow

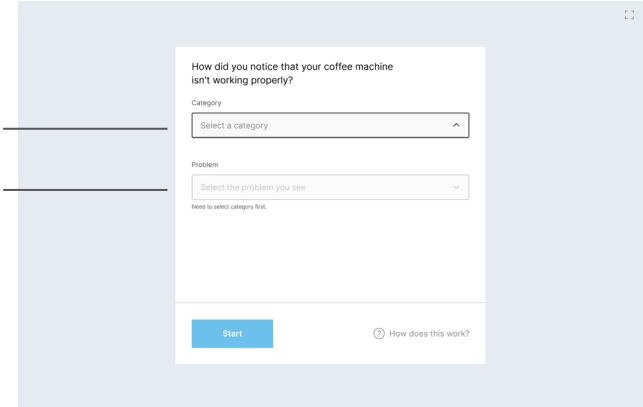
Design



Welcoming page



Question



Main symptom selection

Conclusion & Next steps

Now that we have both the backend decision tree and the website UI we can test if users are able to navigate the digital interface. We have defined a process from start to finish on how the user flow should look, by building a digital prototype we can test if those elements work as intended. Nevertheless, as mentioned before, the following tests are going to be focused on how participants navigate the UI, rather than the decision tree itself. So while the testing will provide valuable data on the interface, it's not going to help in evaluating the effectiveness of the decision tree.

NOTE: All the screen designs can be found in the Final Product section.

2.2.2 TEST Nº1 OF THE WEBSITE

Intro

In the first usability test of the website we are going to look into how the participants navigate the interface and if they understand the different UI elements. Therefore, the research question is “What elements of the UI obstruct the navigation of the website?”

Method

This test is going to be carried out with 5 participants over a video call. They are going to receive a description of the symptoms of a faulty coffee machine, and from that point on they have to use the website until they pinpoint what element is responsible for the fault. The prototype is going to be developed with Figma, so that it’s easy to share with the participants. During this test we are looking for qualitative information on what visual elements are not understood or cause confusion. This test will allow us to adjust the design for a smoother interaction so that we can carry out a second test, in which we see the impact of the improvements.

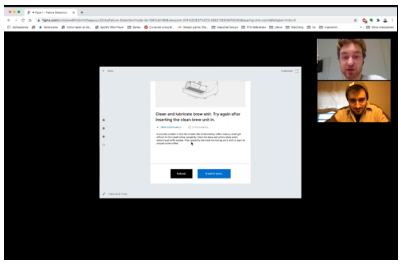


Fig. 0. Videocall testing

Results

This first test showed that the bottleneck of the process is the selection of the main symptom. The categories of “Output”, “Product behaviour” and “Others” were not clear enough for all of the participants. Additionally, if the main symptom didn’t match exactly what they had written in the symptom description, they kept looking for other options.

When it comes to the navigation of the website, there were two options to go back to the previous slide: the back arrow and clicking on the bullet of the previous slide. These two options were essentially the same but it caused some confusion on how far they were exactly backtracking if they clicked on them. One participant mentioned that he was afraid that he would go way back to the homescreen and lose all progress. Finally, two of the participants mentioned that it was not clear which one was the last question before finalizing the process, and they had concerns that once the process is finished they couldn’t go back.

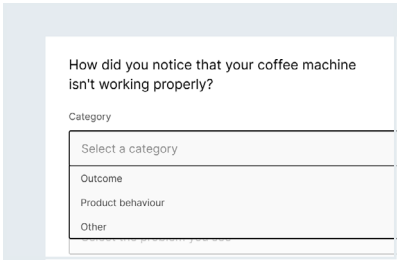


Fig. 0. Categories of main symptoms

Fig. 0. “Go back” option on in the navigation bullets

Conclusions & Next steps

For the next version, the website is going to display all the main symptoms together. This will make the selection process quicker and eliminate the need for categories, but it can cause confusion by the large amount of options we see displayed in one single screen. Once a main symptom is selected, the website should also display a more broad description of that symptom, so that the users know what includes and excludes that category. For the navigation of the website, the back option of the bullets should be removed, so that the back arrow is the only way to access the previous slide. In that way, the bullets just show the position and allow you to go back to the home screen. For the last question slide, the button that leads to the last slide should be a different color. That way the user knows if the next step is another question or the end of the process.

Fig. 0. Re-design of the Main symptom selection

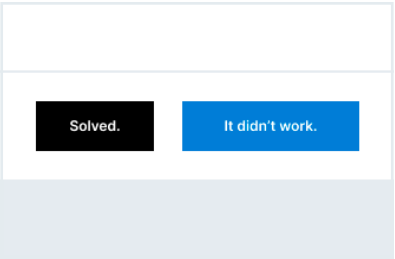


Fig. 0. Change of color to highlight end of the process

2.3.2 TEST Nº2 OF THE WEBSITE

Intro

After applying the changes detected in the first test, we will carry out a second test with the same goals and following the same process. Three of the participants also took part in the first test, while two others are new to the fault diagnosis website. As mentioned, the research question is the same as in the previous test: “What elements of the UI obstruct the navigation of the website’s interface?”

Method

The method of testing is going to be the same as the first test of the website. The participants will receive a description of the symptoms of a faulty coffee machine, and then they have to use the website until they pinpoint what element is responsible for the fault. Again, we are looking for the qualitative information on what visual elements are not understood or difficult in the navigation process. This test should allow us to polish the final details of the website’s interface.

NOTE: All the screen designs can be found in the Final Product section.

Results

The process of selection of the main symptom ran much more smoother this time. It’s still the step that takes most time, but the bigger font and lack of categories made it much smoother than in the first run. Additionally the description text that appears once the choice is selected reassures the participants that the choice they took fits their main symptom. The two new participants had no trouble using the “Back” option, but one mentioned that the home icon should be more recognizable, since now it can be mistaken as an up arrow. For the location of the external links to tutorials and tools, there was some disagreement amongst participants; while they all mentioned that they wanted the button to be near the comments, because at the bottom it’s easier to miss, some said that the button should be on all question slides while others said it should be just present on the questions that have difficult words or need for external help.

Conclusions & Next steps

With the selection of the main symptoms improved, the participants were able to navigate the website without major problems. Now it’s a matter of adjusting small details like icons, text size and more specifically the position of the tutorials & tools button so that the interactions runs a bit faster than it did in this cycle. Nevertheless, once these design changes are applied the website won’t be tested again for this project. The overall interaction flow has already proven to work. If in the future there needs to be another test to adjust small details, it should be done with a larger and more diverse group of participants, preferably once the COVID-19 pandemic is under control or completely over.

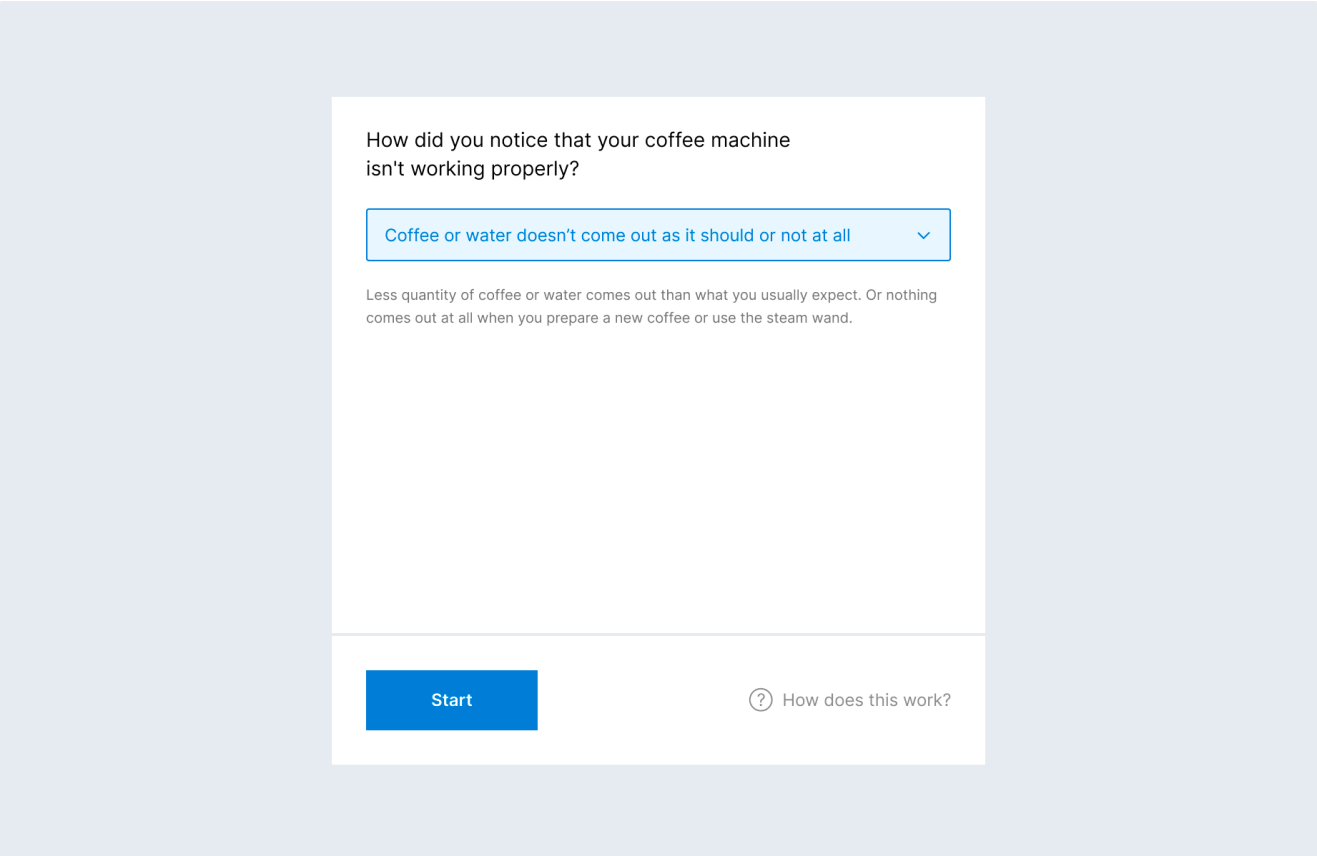


Fig. 0. Description of the main symptom selected

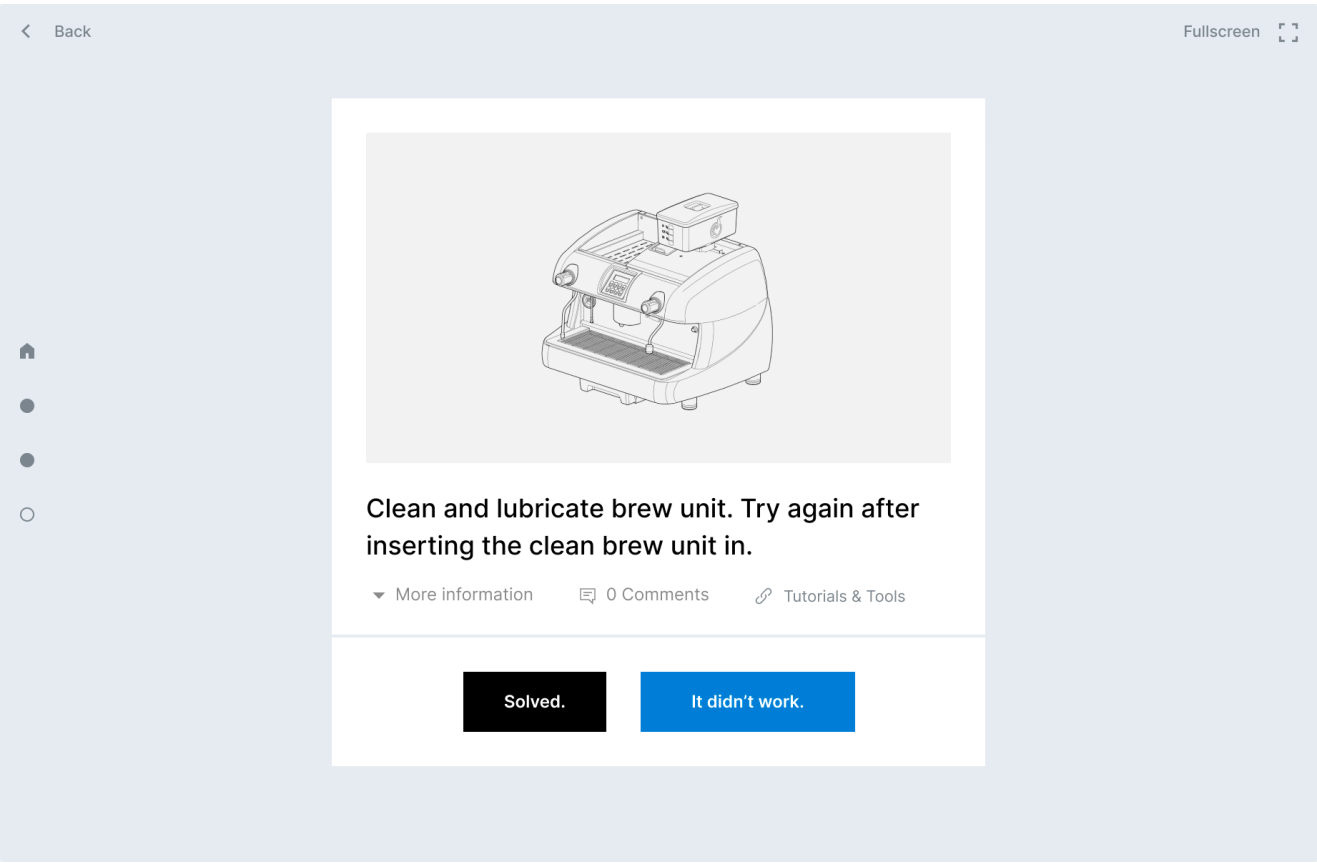


Fig. 0. Final design of the question slide

Final Product

3.1 Tool selection

FROM LEFT TO RIGHT: Cylindrical brush · Frontal brush · Food-grade lubricant
Screw bits: Philips (PH1 to PH5), Security Torx (TX8H to TX25), Oval screw, Flathead (2 to 5) · iFixit Precision Bit Driver · Whia 4mm magnetic extender
iFixit Spudger · Custom heavy spudger · iFixit Metal Spudger (shovel-triangle)

The final selection of tools can be divided into three categories; Maintenance tools, Screws bits with extender and spudger tools. This selection offers all the necessary tools independently of what bean-to-cup coffee maker you own and what repair you need to carry out.

The cylindrical brush and the frontal brush can reach areas that you can't access with a wipe or a paper towel, allowing the coffee maker owner to thorowlly remove all residue that can cause bacteria or mold. The food-grade lubricant ensures that all moving mechanisms (especially the brew unit) work correctly for a long period of time, avoiding wear due to the constant friction. Manufacturers recommend to lubricate the brew unit each 2 or 4 months depending on how many coffees you drink per day, so the lubricant becomes one of the most relevant products in the maintenance of the bean-to-cup machines.

The product based research has shown us what screw bit types we need to open up 44 different coffee makers. During this analysis we have seen that the screw type variety is quite narrow, and we can be certain that we will be able to open up any bean-to-cup and capsule machine if we provide security torx, philips, flathead and oval screws bits. Additionally, the new addition of a rigid and magnetic extender allows the consumer to reach with precision those screws that are hard to access using only the driver.

Prying open the different plastic parts and cases is the most difficult task for consumers. The fear of breaking plastic fixtures and snap fits makes this a challenging process especially for newcomers. At the same time, some plastic cases have multiple joining points and require a great deal of force to open up. In order to offer assistance from the most delicate prying option to the toughest one, we include a plastic spudger for the fragile prying, a shovel-triangle iFixit metal spudger for precise and strong prying and a heavy spudger than can pry open even the toughest cases. The availability of multiple spudgers also allows the consumer to keep the plastic parts from snapping back into place, providing a major advantage for plastic cases with multiple snap fits.

The frontal brush, cylindrical brush, lubricant and extender are available to purchase from other manufacturers, since they aren't present in the current iFixit portfolio. In the case of the lubricant, as already mentioned, there is a business opportunity for iFixit to provide their own branded lubricant, which is a product that consumers will periodically need to buy to carry out proper maintenance. There aren't many coffee maker brands that sell their own branded lubricant, shops usually sell lubricants from third party manufacturers with no reputation in the coffee market or the repair world. This leaves a market gap for iFixit to offer a product consumers will trust thanks to the reputation iFixit has in repair. Finally, the heavy spudger is the only tool we had to specifically design for this toolkit and, while it still needs improvement to tackle the fear of consumers of damaging plastic parts, it's an essential tool to access those coffee machines that have strong plastic fixtures and snap fits. All the other tools included are already available in the iFixit portfolio.

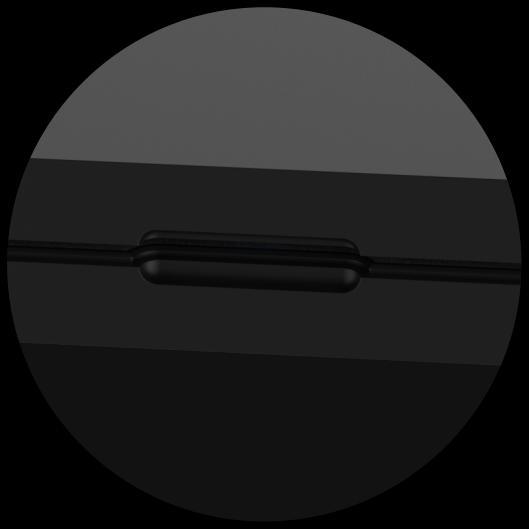
MANUFACTURING

The only tool we have to manufacture is the heavy spudger. Metal spudgers are usually produced by a combination of die cutting and press rolling to get the desired size, in our case we will also need to grind the edges to get the desired roundness and smoothness. Once we have the metal blade in the desired form, we will need to overmold the plastic handle. The exact process can vary from one manufacturer to the other, so it's important to consult the selected manufactured before starting the production

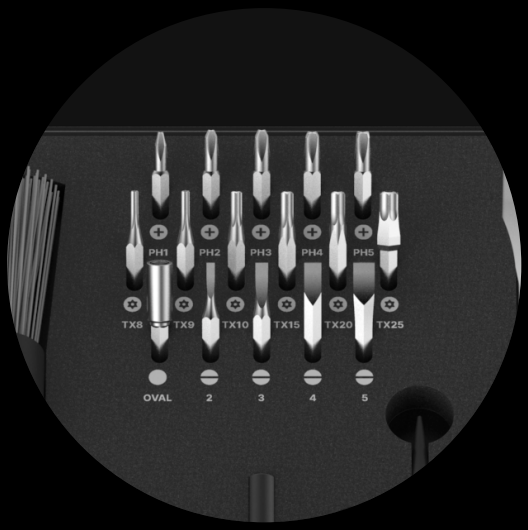
Toolbox

The toolbox is divided between the section for tools and an empty storage area where the consumers can deposit the specific maintenance products and replacement parts depending on the coffee maker model they own. This allows us to have all the necessary products to carry out maintenance and repair into one single unit. Whatever technical problem consumers have with their coffee machine, they have all the necessary items in one place.

The total size of the current prototype is 230×230×140mm. Compared to other current iFixit tool boxes, this design incorporates a groove to help open the cover, a numerically organized space for the screws and icons which are easier to read thanks to their higher contrast.



Groove for accessibility

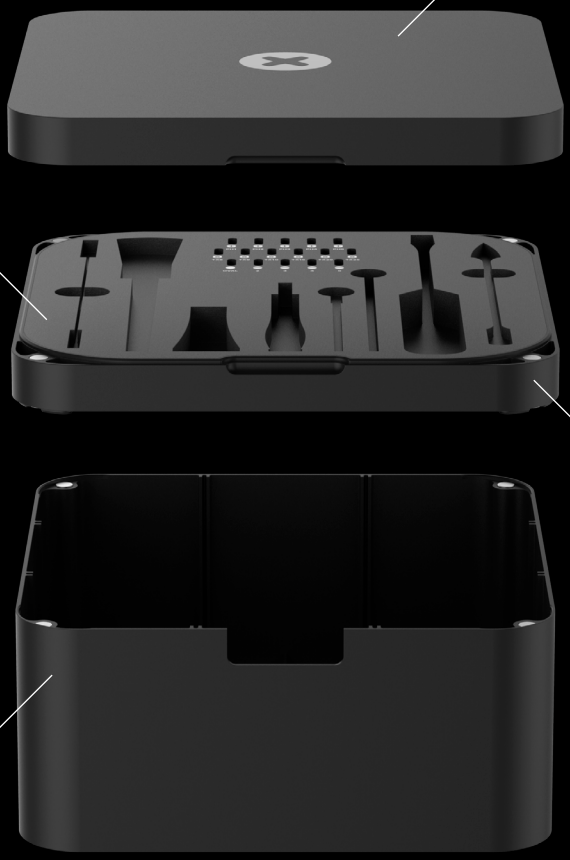


Icons with higher contrast

Organization space for screws

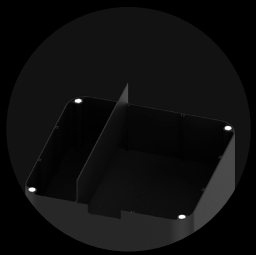
TOP COVER: This plastic part has an overall roughness in all it's surface with the exception of the iFixit logo, the "Space for screws" label and the organization numbers, which need to be slightly embedded and have a shiny finish for easier readability. This part also includes four magnets to adhere it to the tool case.

TOOL FOAM: The EVA foam is identical to the current iFixit one with the exception that the icons are post-printed for higher contrast.



TOOL CASE: The tool case incorporates the EVA foam where the tools are stored. It has four magnets on the top and four magnets on the bottom. It also has four pads at the bottom so that it can be deposited on top of the table. This case fits into the top cover in the same way current iFixit cases fit with each other.

STORAGE BOX: The storage box has four magnets to close it with the tool case. It incorporates eight U shaped nerves to add major rigidity and to serve as rails if the consumer wants to divide the inner space.



At the bottom there is a cardboard cutout with a QR code. This leads the consumer to create a calendar reminder to carry out maintenance.

Only the basic maintenance products fit inside

There is an opportunity to reduce the height of the toolbox by reducing the storage space height. This would allow for a toolbox that is 60mm shorter, having enough space to store cleaning tablets, descaling tablets and a water filter, but it leaves little to no space if the consumer wants to store more things.

MANUFACTURING

Tha plastic cases can be manufactured in the same way iFixit currently manufactures their toolboxes. The thickness of the plastic parts should be adjusted depending on the material used and the walls should have the adequate de-molding angle. The manufacturer should be contacted to get the correct thickness and draft angle, but the current geometry is already designed to easily incorporate those changes.

The top cover will need to have sections that are more shiny like the logo, the organization labels and the organization number. This can be achieved by post processing the injection mod to achieve different roughness in the plastic part.

In order to achieve icons with higher contrast, the icons should be printed on top of the EVA foam once it has been milled or laser cut.

Decision tree for fault diagnosis & Website interface

The decision tree provides a model to follow during the fault diagnosis process. It's goal is to associate specific symptoms that can be perceived by anybody to specific fault causes, without the need for technical knowledge on the internal working of the coffee maker model.

Some of the questions come with previous instructions on what the user has to check before answering. Those questions and instructions are related to an element of the coffee maker that could be responsible for the fault. If the user reaches the end of the process (symbolized by the black squares with the white text) without successfully locating the fault, he knows which elements he has checked during the process and are certainly not responsible for the fault.

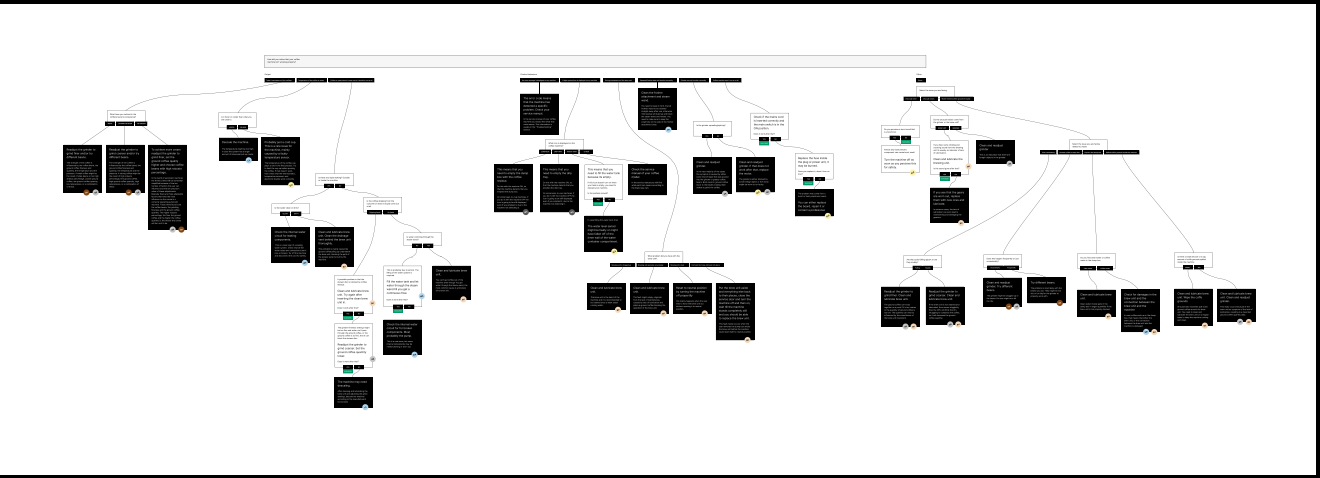
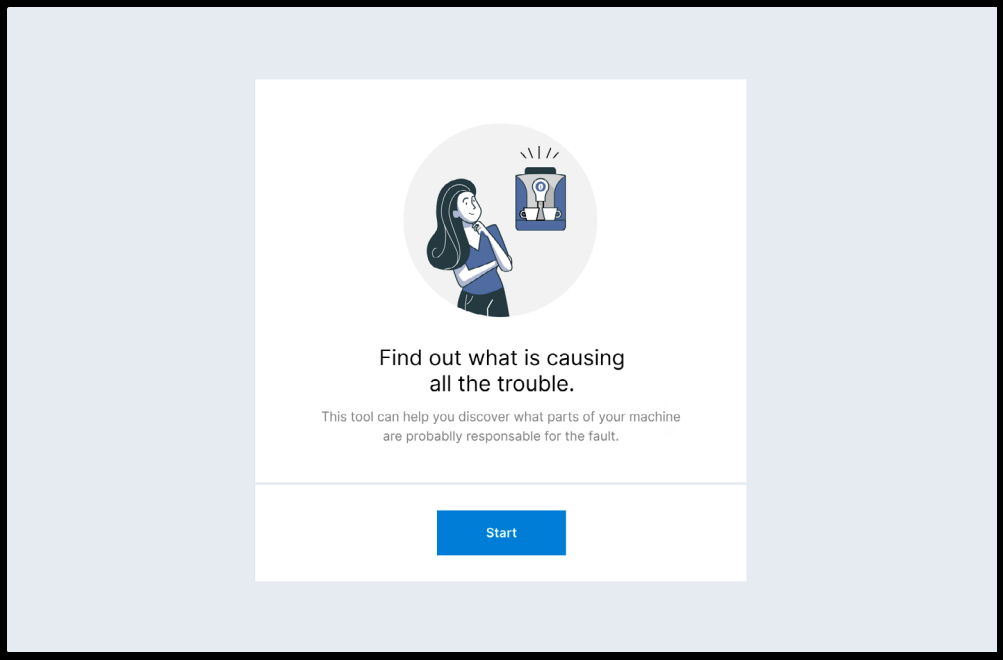


Fig. 0. Full decision-tree. For better readability, a sectioned version is available in the ideation section

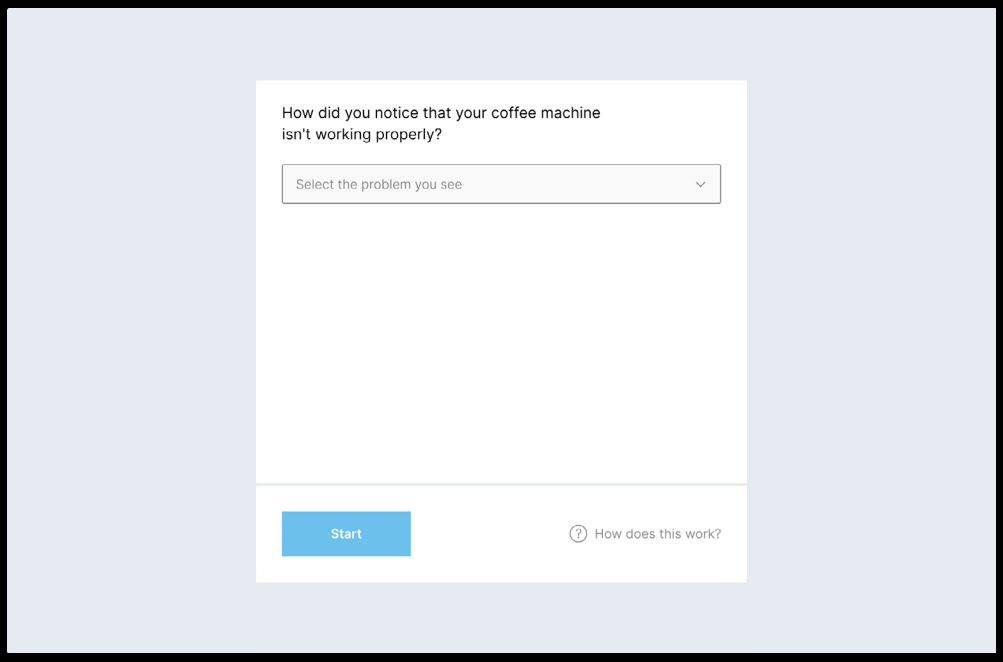
To improve this model we would need to test how current coffee maker consumers perceive these questions and if they understand them. If they are able to identify what the question wants to know and they understand the available answers, the decision-tree will work as intended. Additionally, this model needs to be tested with a variety of coffee makers from different brands, to ensure that the instructions are broad enough to not exclude any specific case.

The visual interface has proven to work as intended after the two tests we carried out in the ideation. However those tests were carried out with fellow students and friends, which make up a very specific type of user. To ensure that people from all ages and backgrounds are able to navigate it, the interface should be further tested with a diverse group of participants.

Full navigation of the website interface.

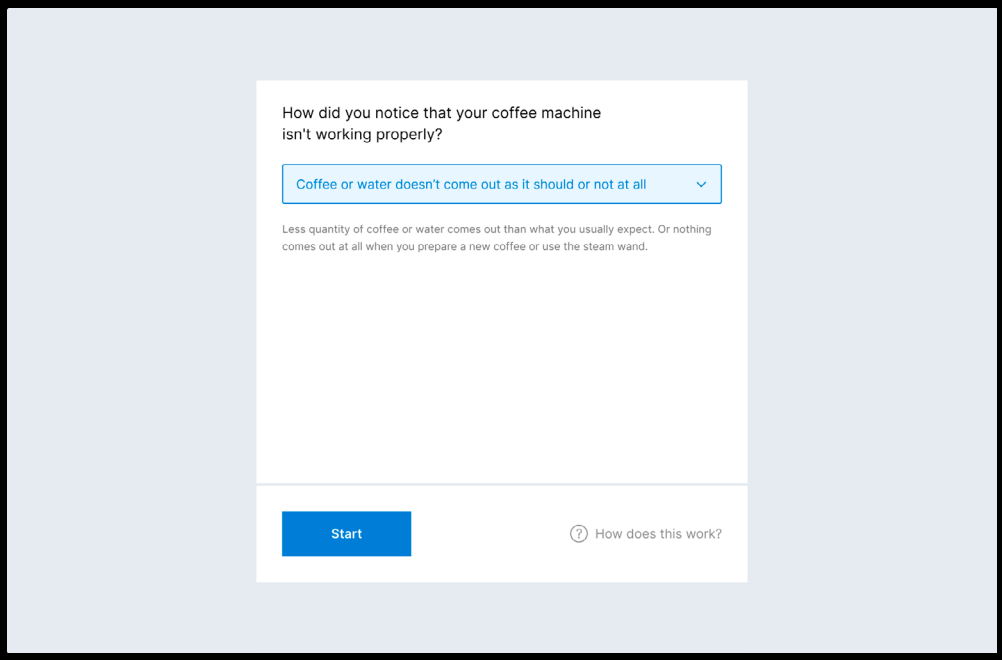


1. Starting screen

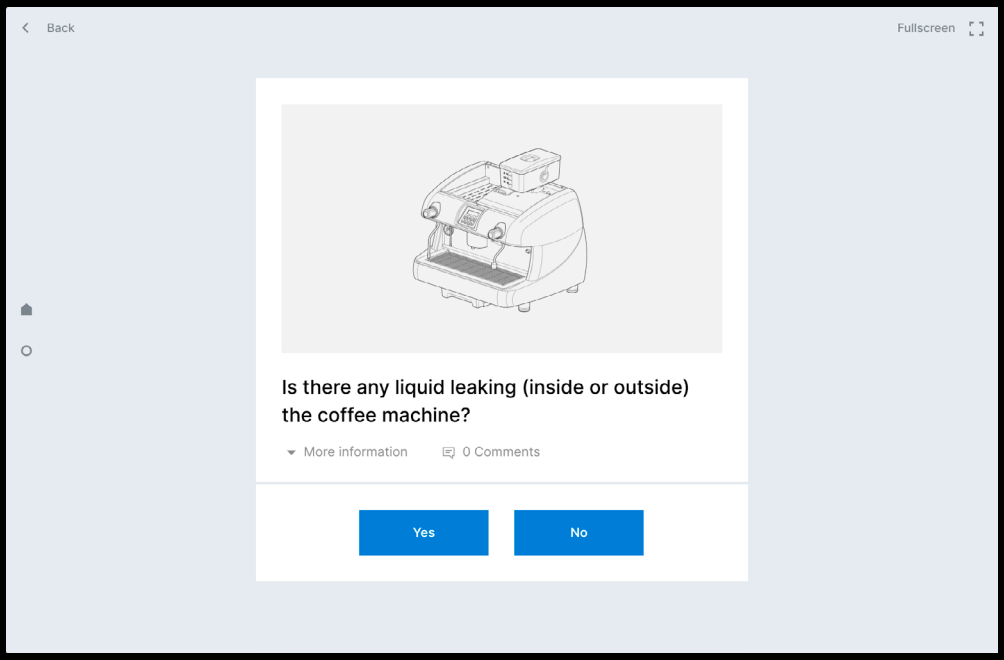


2.0 Selection of main symptom

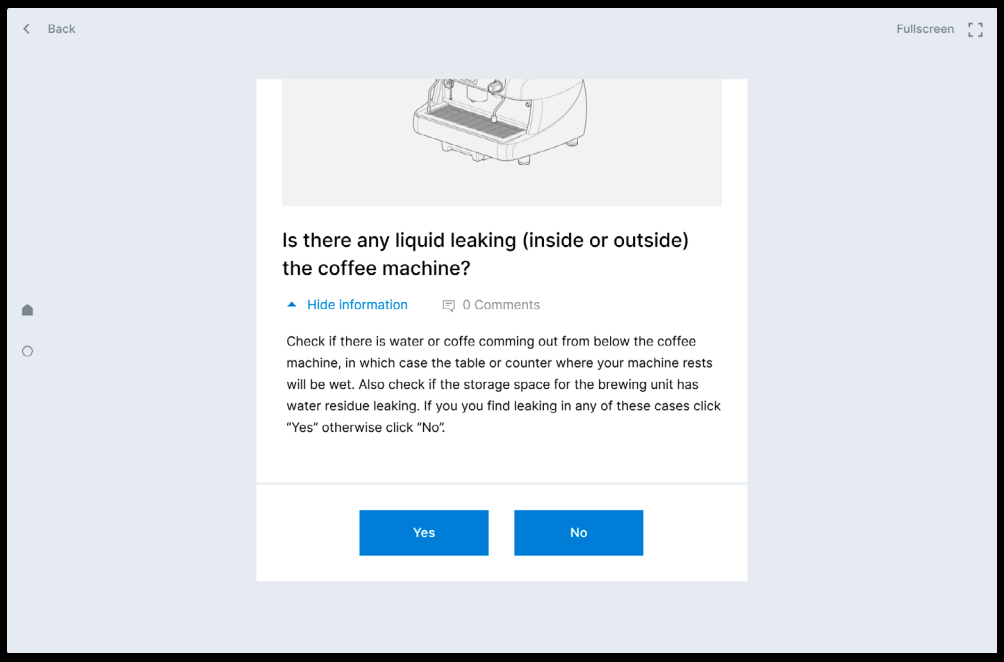
2.1 List of main symptoms in drop down menu



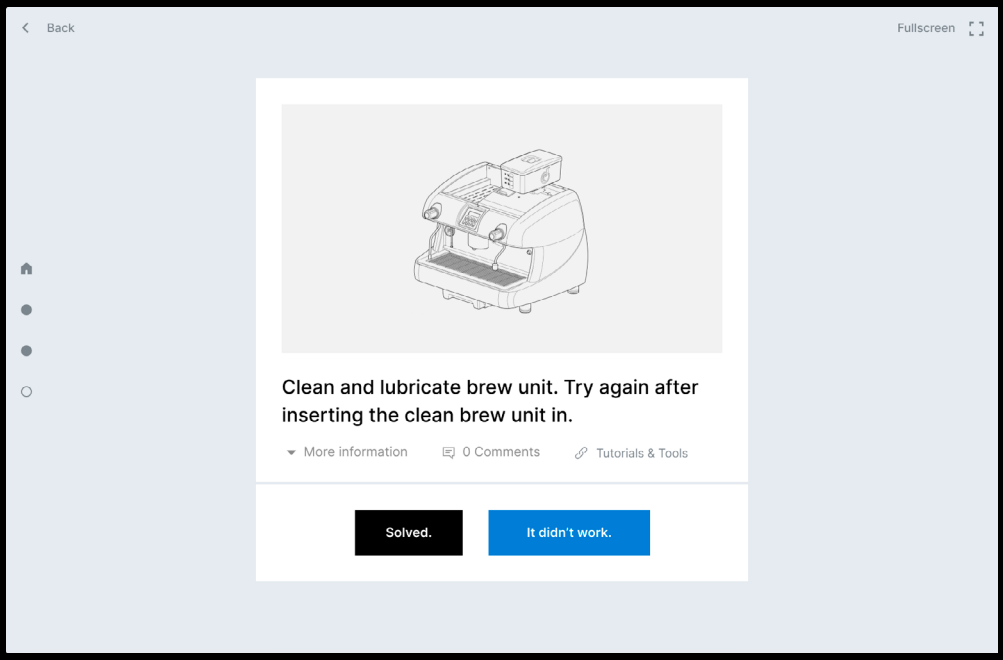
2.3 Confirmation of selection and detailed description of the main symptom



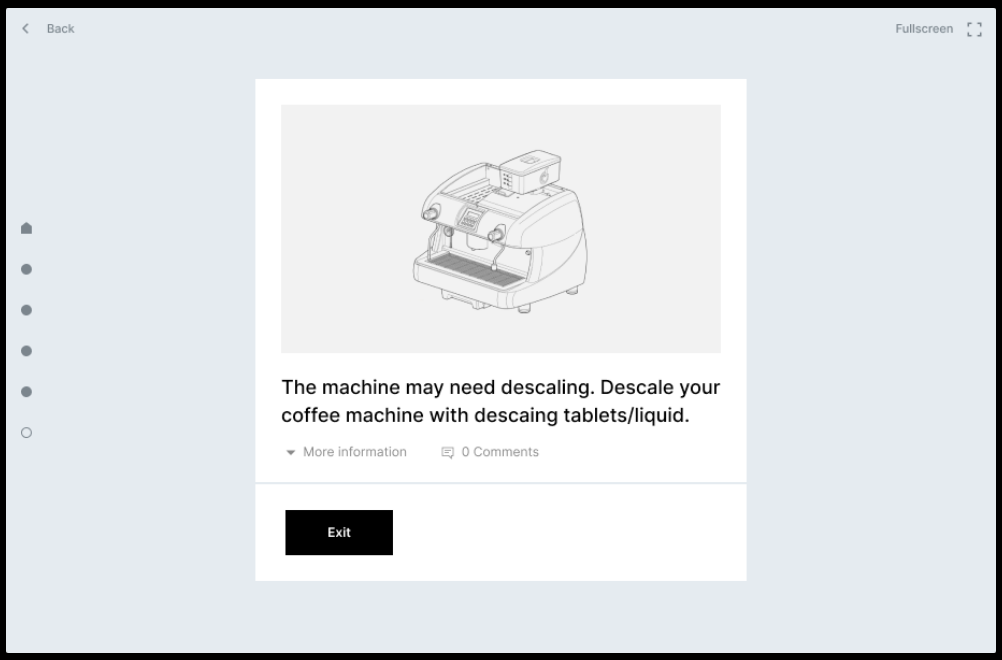
3.0 Question about specific symptom and possible answers



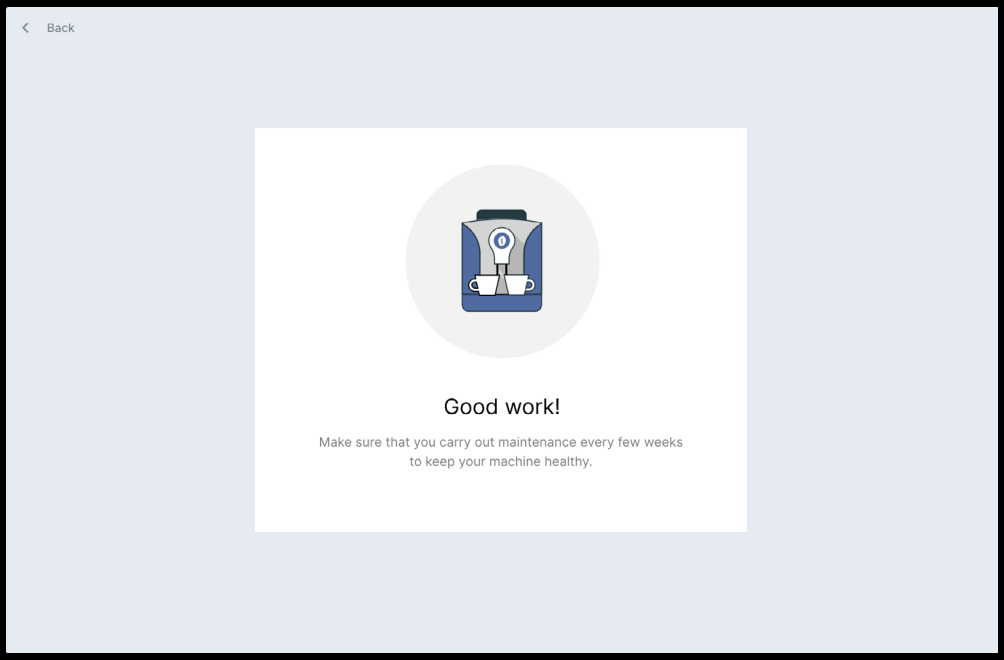
3.1 If the user needs more details they can acces the "More information" tab



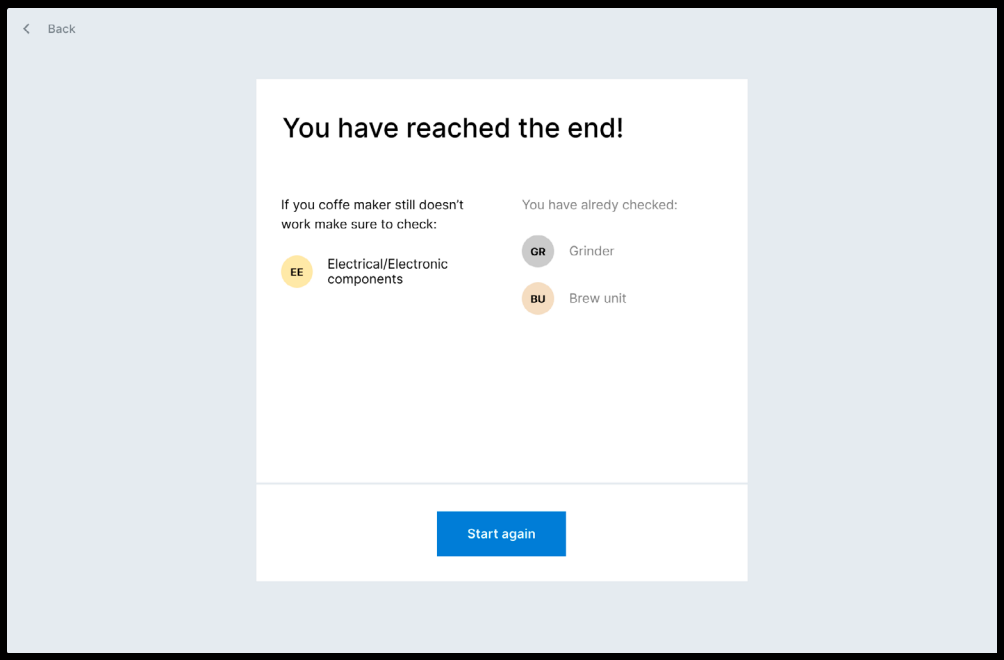
3.2 If one of the answers leads to the end of the process it will be highlighted in black



3.1 In case the decision tree runs out of options the user will be lead to the recap screen



4.0 End screen if the operation was succesful



3.1 Recap screen. If the fault was not detected the guide provides other suggestion which depend on the specific coffee machine the users have.

Conclusions

We've come up with a toolkit that can be used for multiple coffee makers and different repair scenarios, providing a single product that can help consumers extend the useful life of their machines in different ways. While the product based research has allowed us to see that the coffee makers are not so different from one another, it's important to remember that the toolkit has been tested with a single bean-to-cup model, the Jura ENA 7. Further real life testing with coffee makers from different brands can re-assure us that the insights we have extracted from the repair videos are accurate.

Taking into account the importance of the fault diagnosis process, the decision-tree and the website provide a blueprint for a system that can help reduce the barrier to repair for newcomers to the repair world. Yet here again, we need further testing with a wider variety of participants from different age groups and backgrounds. In this way we can make sure that the questions and the instructions are clear regardless of the knowledge and experience consumers have with their product.

This all indicates that the biggest hurdle in this project was the lack of coffee machines to test with and lack of diversity in participants, due to the available budget and to the COVID-19 pandemic. Nevertheless, the additional user testing needed is mainly to adjust smaller details or verify the insights that we already have. It's also important to evaluate the price consumers are willing to pay for this toolkit, since the actual value of this toolkit can only be really appreciated when the consumers are aware of the maintenance that bean-to-cup machines require.

With this project we have provided the tools and the knowledge that are necessary to keep coffee makers working correctly, with the potential of keeping these products functioning correctly for a long time. And as we mentioned at the start of this project, this not only has great benefits for those who can't afford to buy new coffee machines every few years, but also helps reduce the amount of e-waste we send to the landfill, one of the fastest growing waste problems in the European Union.

5.0 Sources

Ellen McArthur Foundation (2013). *What is a circular economy?* Ellen MacArthur Foundation. Available at: https://www.ellenmacarthurfoundation.org/circular-economy/concept

Tim Cooper (2010). *Longer lasting products: alternatives to the throwaway society.* Routledge. Available at: https://books.google.co.uk/books?hl=en&lr=&id=rQUfDAAAQBAJ&oi=fnd&pg=PP1&ots=JJjY7OpsPu&sig=OoqiP2YYJS1HsWVGO7HARhb4oW0#v=onepage&q&f=false

John McCollough (2009). *Factors impacting the demand for repair services of household products: the disappearing repair trades and the throwaway society.* Department of Business and Economics, The Pennsylvania State University-Lehigh Valley, Fogelsville, PA, USA. Available at: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1470-6431.2009.00793.x

Alexander James Gnanapragasam & Christine Cole (2017). *Community repair: enabling repair as part of the movement towards a circular economy. Waste and Resource Management* (WaRM) Conference 2017. Available at: https://www.researchgate.net/publication/317427583_Community_repair_enabling_repair_as_part_of_the_movement_towards_a_circular_economy_conference_presentation_abstract

Eurostat (2017). *Waste statistics - electrical and electronic equipment. EUROSTAT Statistics explained.* Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistics_-_electrical_and_electronic_equipment

Sahra Svensson & Jessika Luth Richter & Eléonore Maitre-Ekern & Taina Pihlajarinne & Aline MaigretCarl Dalhammar (2018). *The Emerging 'Right to Repair' legislation in the EU and the U.S.* UKÄ Environmental Management. Available at: https://portal.research.lu.se/portal/en/publications/the-emerging-right-to-repair-legislation-in-the-eu-and-the-us(34ca32eb-5148-4b33-b82a-d7cfca46c672).html

Martin Charter & Scott Keiller (2016), *The Second Global Survey of Repair Cafés: A Summary of Findings*

Lara Houston & Steven J. Jackson & Daniela K. Rosner & Syed Ishtiaque Ahmed & Meg Young, & Laewoo Kang (2016). *Values in Repair.* Reclaiming Repair. Available at: https://www.researchgate.net/publication/301931640_Values_in_Repair

Weetman, C. (2016). *A Circular Economy Handbook for Business and Supply Chains: Repair, Remake, Redesign, Rethink* (1st ed.). Kogan Page.

Inertia engineering (2020) *The Three Phases of Prototyping.* Available at: https://inertiaengineering.com/three-phases-prototyping/

Coffe Society (2020) *Bean to Cup Coffee Machine Cleaning.* Available at: https://www.caffesociety.co.uk/bean-to-cup-coffee-machine-cleaning

NSF (2011). *Germs in the Kitchen*. NSF. Available at: https://d2evkimvhatqav.cloudfront.net/documents/2011_NSF_Household_Germ_Study_exec-summary.pdf

Dietlinde Quack (2011) *Coffee Machines - with Focus on Espresso Machines*. Öko-Institut- Institute for Applied Ecology. Available at: https://www.ecotopten.de/sites/default/files/product_criteria_coffeemachines_2011.pdf

Goldstein (2020) *Global Coffee Machine Market Overview 2017-2030*. Goldstein Market Intelligence. Available at: https://www.goldsteinresearch.com/report/global-coffee-machine-industry-market-analysis

Future Market Reports (2020) *Europe Automatic Coffee Machines Market Research And Manufacturers Analysis Report 2019-2025*. Future Market Reports. Available at: https://www.marketresearchfuture.com/reports/coffee-machines-market-8411

Christopher. M. Lott (2010) *Repairing a Jura Nespresso Machine*. Medium. Available at: https://chrisinmtown.medium.com/repairing-a-jura-nespresso-machine-a3a2aabaa18f

Jura Parts (2020) *Jura Parts & Repair*. Available at: https://www.jura-parts.com/cindex.asp

Mohammadhamed Ardakani & Mahdieh Askarian & AhmedShokry & Gerard Escudero & Moisès-Graells & AntonioEspuña (2016) *Optimal Features Selection for Designing a Fault Diagnosis System. Computer Aided Chemical Engineering*. Available at: https://www.sciencedirect.com/science/article/pii/B9780444634283501909?casa_token=mGBABqW_E9AAAAAA:fpecnBrX-GULqYysungCUuepAgdj7AW5VMgu0NSDuESrv4xNc-SPkv6N6-w9Axz0ta0dQgxa4_UI

JennAir (2020) *Self Diagnosis - Error Codes*. JennAir. Available at: https://producthelp.jennair.com/Cooking/Built-In_Coffee_Makers/Messages_or_Error_Codes/SELF_DIAGNOSIS_-_Error_Code_-_Built-In_Coffee_Maker

Pozo Arcos, Beatriz & Bakker, C.A. & Flipsen, Bas & Balkenende, Ruud. (2020). *Practices of fault diagnosis in household appliances: Insights for design*. Journal of Cleaner Production. 265. 121812. 10.1016/j.jclepro.2020.121812.

Scott Mitchell (2018): *Narratives of Resistance and Repair in Consumer Society,* Third Text, DOI: 10.1080/09528822.2018.1459110

Cooper, Tim. (2004). *Inadequate Life?Evidence of Consumer Attitudes to Product Obsolescence*. Journal of Consumer Policy. 27. 421-449. 10.1007/s10603-004-2284-6.

Lemonlight (2020) *How TikTok Is Affecting the Future of Video*. Lemonlight. Available at: https://www.lemonlight.com/blog/how-tiktok-is-affecting-the-future-of-video/

Coffee Friend (2020) *How to look after a bean-to-cup coffee machine*. Coffee Friend. Available at: https://www.coffeefriend.co.uk/blog/how-to-look-after-a-coffee-machine/#:~:text=%E2%80%93%20We%20recommend%20cleaning%20the%20brewing,back%20into%20the%20coffee%20machine.

Shailendra Mudgal & Benoît Tinetti (2011) *Non-Tertiary Coffee Machines*. European Commission (DG ENER). Available at: https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/lot25-non-tertiary-coffee-machines/final-report-task1.pdf

Patkin, Michael. (2001). *A CheckList for Handle Design.* Available at: https://www.researchgate.net/publication/237594317_A_CheckList_for_Handle_Design

The Espresso Shop (2021) *A Basic Troubleshooting Guide For Espresso Machines*. Available at: https://www.theespressoshop.co.uk/en/Troubleshooting-Guide-For-Espresso-Machines/cc-17.aspx

Mr. Bean2Cup (2020) *Guide for troubleshooting*. Available at: https://www.mrbean2cup.co.uk/troubleshooting

Hedstrom, G., Hedstrom, P., & Tremore, J. O. (2005). *How to Fix Everything For Dummies* (1st ed.). For Dummies.

Service Manuals for: Jura ENA 8, Siemens EQ6, De'Longhi PrimmaDonna

Danny Halarewich (2016) *Reducing Cognitive Overload For A Better User Experience*. Available at: https://www.smashingmagazine.com/2016/09/reducing-cognitive-overload-for-a-better-user-experience/

System Reliability Theory: Models, Statistical Methods, and Applications, Marvin Rausand & Arnljot Hoylan, Wiley Series in probability and statistics—second edition 2004

Loss Prevention Reference Note (2004) Principles of Hand Tool Selection. Liberty Mutual. Available at: http://www.libertymutualimages.com/LMRISpdfs/LP190_Hand_Tools.pdf

List of YouTube repair videos consulted during the Product Based Research

Brand	Model	Type	Price	Source
Jura	E8	Bean-to-cup		https://www.youtube.com/watch?v=uAU8UHbJjR0&feature=youtu.be&ab_channel=Jura-parts & https://www.jura-parts.com/Jura-E8-PEP-Parts-s/297.htm
Jura	A1	Bean-to-cup		https://www.youtube.com/watch?v=A4wwJ7QHyEY&ab_channel=komtra.de
Jura	E6	Bean-to-cup		https://www.youtube.com/watch?v=TFNT0xughZw&ab_channel=WillemOldemans
Jura	ENA8	Bean-to-cup		https://www.youtube.com/watch?v=BninOuDkyR8&ab_channel=Jura-parts
Jura	D6	Bean-to-cup		https://www.youtube.com/watch?v=7HbFzfVb5vs&ab_channel=BNDKaffeestudio & https://www.juraprofi.de/Jura-Ersatzteile/Schrauben-und-Klammern:::38_336.html
Jura	GIGA	Bean-to-cup		https://www.youtube.com/watch?v=Nn-Rj1PVe8w&feature=youtu.be&ab_channel=Jura-parts
DeLonghi	Perfecta	Bean-to-cup		https://www.youtube.com/watch?v=Yq9tBpAFHoY&ab_channel=ShoppersTherapy
DeLonghi	PrimaDonna	Bean-to-cup		https://www.youtube.com/watch?v=NFgyxT97ZHU&ab_channel=myworks
DeLonghi	Eletta	Bean-to-cup		https://www.youtube.com/watch?v=NFgyxT97ZHU&ab_channel=myworks
DeLonghi	Magnifica	Bean-to-cup		https://www.youtube.com/watch?v=5XRFeyoahsg&ab_channel=myworks
DeLonghi	Citiz	Capsule		https://www.youtube.com/watch?v=6JkR_LcUJ-o&t=604s&ab_channel=Reparatumismo
DeLonghi	Lattissima One	Capsule		https://www.youtube.com/watch?v=Q5oH5HX3pZw&ab_channel=KAFFEE.SUPPORT
Krups	XP & EA(Old)	Bean-to-cup		https://www.youtube.com/watch?v=uRZuPRPXp4E&ab_channel=%D0%90%D0%BD%D0%B0%D1%82%D0%BE%D0%BB%D0%B8%D0%B9%D0%A6%D1%83%D1%80%D0%BA%D0%BE%D0%B2 & https://v
Krups	Evidence	Bean-to-cup		https://www.youtube.com/watch?v=PanBR_5DbnA&ab_channel=BenjaminT.
Krups	Barista (EA90)	Bean-to-cup		https://www.youtube.com/watch?v=pihWGtaidvA&ab_channel=ChrisCiapala
Krups	Master (EA88)	Bean-to-cup		https://www.youtube.com/watch?v=kCS-s1fHjro&ab_channel=NADINEBAUT
Krups	Atelier	Capsule		Moon & https://www.youtube.com/watch?v=41oyKrW2cuc&ab_channel=A2BProductions
Krups	Pixie	Capsule		https://www.youtube.com/watch?v=fkR5Fz91LHI&t=9s&ab_channel=Oniyaki
Krups	Expert	Capsule		https://www.youtube.com/watch?v=Jx3p6MsUTcQ&t=372s&ab_channel=UsualRepairs
Philips	Saeco Xelsis	Bean-to-cup		https://www.youtube.com/watch?v=0YR-xtacx1U&ab_channel=SuperFastDriver & https://www.youtube.com/watch?v=IlGBzeGVB3k&ab_channel=MilenStoitsev
Philips	Saeco PicoBarist	Bean-to-cup		Kidna: https://www.youtube.com/watch?v=0aMOaSqai5I&ab_channel=ArnoldArnraser
Philips	2200	Bean-to-cup		Kidna: https://www.youtube.com/watch?v=4o8_XRGHt6E&ab_channel=LucaTrombin & https://www.youtube.com/watch?v=bfvNOz1NzVU&ab_channel=eHaJo
Philips	3200	Bean-to-cup		Small peak: https://www.youtube.com/watch?v=n95MJBPDsC0&ab_channel=Philips
Philips	5000	Bean-to-cup		https://www.youtube.com/watch?v=4o8_XRGHt6E&ab_channel=LucaTrombin
Philips	Senseo HD7XXX	Capsule		https://www.youtube.com/watch?v=IhnihFjmaVw&ab_channel=DickvanderKraats
Bosch	VeroCafe	Bean-to-cup		https://www.youtube.com/watch?v=vkvdZThfRrM&ab_channel=komtra.de & https://www.youtube.com/watch?v=fnWJKfY9ge8&ab_channel=EdiBeil6
Bosch	VeroCup	Bean-to-cup		https://www.youtube.com/watch?v=d5QI5ljhJUA&ab_channel=%D0%9A%D0%BE%D1%84%D0%B5%D0%BC%D0%B0%D1%81%D1%82%D0%B5%D1%80
Nespresso	Vertuo Next	Capsule		https://www.youtube.com/watch?v=duK5sr3wLwU&ab_channel=It%27sDoable%21
Nespresso	Prodigio	Capsule		https://www.youtube.com/watch?v=3YspXcHkhug&ab_channel=MrSjirafje
Nespresso	U Series	Capsule		https://www.youtube.com/watch?v=1pk_sqbVfS0&ab_channel=AdrianB.
Siemens	EQ.6	Bean-to-cup		https://www.youtube.com/watch?v=bpdAIyzgwKA&ab_channel=komtra.de
Siemens	EQ.3	Bean-to-cup		https://www.youtube.com/watch?v=zAKH0bbgCbQ&ab_channel=FrankFeil
Siemens	EQ.9	Bean-to-cup		https://www.youtube.com/watch?v=wX80n57b4k4&ab_channel=real.repair
Melitta	Lattea	Bean-to-cup		https://www.youtube.com/watch?v=50dFNIIY6Gs&list=PL9pdlQk2PP8QNsFGvoAcr3gEk_5VyFGYS&index=2&ab_channel=komtra.de
Melitta	Solo	Bean-to-cup		https://www.youtube.com/watch?v=50dFNIIY6Gs&list=PL9pdlQk2PP8QNsFGvoAcr3gEk_5VyFGYS&index=2&ab_channel=komtra.de
Melitta	Barista /Bistro	Bean-to-cup		https://www.youtube.com/watch?v=wwuyYGrFFI0&list=PL9pdlQk2PP8QNsFGvoAcr3gEk_5VyFGYS&index=14&ab_channel=komtra.de
Miele	CM5000 Line	Bean-to-cup		https://www.youtube.com/watch?v=ktkopAc7z58&ab_channel=coffeemakers.de & https://www.youtube.com/watch?v=FWWjP2HcCIU&ab_channel=DISUSEREUSE
Miele	CM6300	Bean-to-cup		https://www.youtube.com/watch?v=VidahkX2xL8&t=257s&ab_channel=coffeemakers.de
Tchibo	Esperto Caffè	Bean-to-cup		https://www.youtube.com/watch?v=9TM1L7WJp54&ab_channel=KaffeeTV
Nivona	CR 740	Bean-to-cup		https://www.youtube.com/watch?v=KQuNd97c6_Q&list=PL9pdlQk2PP8TPMPeJnaXeNz3G7LwdSQwf&index=2&ab_channel=komtra.de
Nivona	CR 830	Bean-to-cup		https://www.youtube.com/watch?v=cbf_UVPVHJY&t=7s&ab_channel=doit4you
AEG	CS 5000	Bean-to-cup		https://www.youtube.com/watch?v=tT-bCURMMVk&ab_channel=olegpl
Saeco	Minuto	Bean-to-cup		https://www.youtube.com/watch?v=IlGBzeGVB3k&t=535s&ab_channel=MilenStoitsev
Saeco	Odea giro	Bean-to-cup		https://www.youtube.com/watch?v=CKwxxUgQu7g&ab_channel=MiroslavStoicev
Saeco	Intelia	Bean-to-cup		https://www.youtube.com/watch?v=fHAIjA8MR6k&ab_channel=MilenStoitsev
Saeco	Incanto	Bean-to-cup		https://www.youtube.com/watch?v=9rs-3Y2FB6U&t=64s&ab_channel=MilanGajic
Saeco	Lirika	Bean-to-cup		https://www.youtube.com/watch?v=bjKt9US2h8M&ab_channel=CoffeeTeks