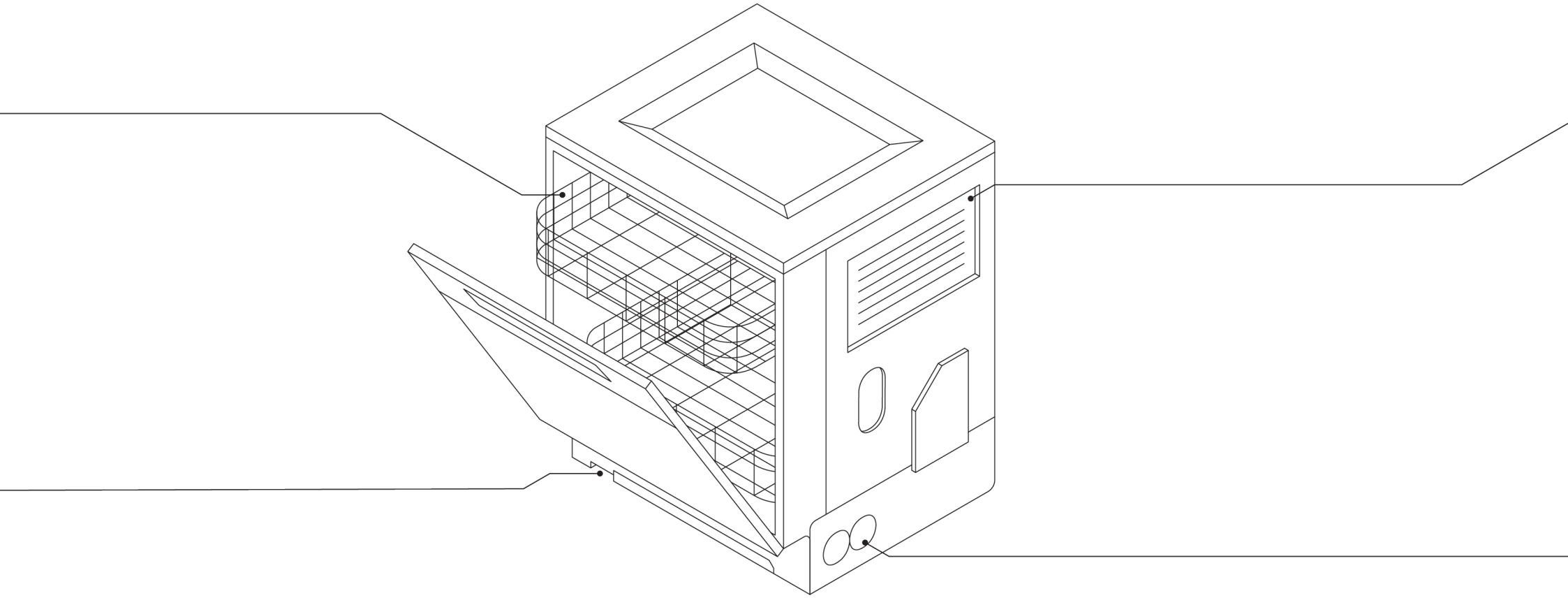
PRACTICAL SOLUTIONS FOR INCREASING THE WILLINGNESS TO REPAIR OF ATAG DISHWASHER USERS



Design for Interaction - Master Thesis

Raf Baljet

"By looking at products differently, repair challenges the prevailing conception about products as throwaway items. By repairing products, their intrinsic value is acknowledged and they are treated respectfully. This can lead to a more sustainable and responsible consumption culture, in which products have longer lifetimes and are discarded of less quickly" (McLaren et al. 2020).

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Master graduation thesis
Practical solutions for increasing the willingness to repair of ATAG dishwasher users

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This graduation project explores how ATAG can encourage more self-repair among its dishwasher users by designing interventions that increase willingness to repair. Despite the growing urgency of sustainability and circular product use, many consumers still choose to replace rather than repair broken appliances, often due to motivational and practical barriers. The goal of this project was to develop practical, design-driven solutions that help overcome these barriers and support consumers in completing successful self-repairs.

The project began with an extensive literature review, revealing that the decision to repair is not made in a single moment but is influenced by a range of factors throughout the entire repair journey. Key psychological and behavioural models, such as the Theory of Planned Behaviour and the Fogg Behaviour Model, were used to identify opportunities for intervention. These insights were complemented by field research, including interviews with ATAG service mechanics and context exploration, to better understand the real-world repair context and consumer behaviour.

Three distinct intervention moments were defined: changing the replacement mindset before a failure occurs, supporting users during fault diagnosis, and guiding them through the actual repair. Based on these moments, three design concepts were developed: a calendar that subtly encourages repair thinking, a structured digital fault diagnosis tool, and IRIS, a voice-guided AI repair assistant. Each concept was prototyped and tested in an iterative process to assess usability, effectiveness, and alignment with the intended interaction qualities. The repair instruction concept was chosen for further development and a second evaluation round to provide ATAG with a more refined concept.

The results showed that consumers appreciated personalised and well-structured support, particularly regarding fault diagnosis and real-time repair guidance. While the calendar proved helpful in raising awareness, users emphasised the significance of visual appeal and contextual relevance. The AI assistant concept, IRIS, was well-received for its conversational and reassuring guidance, although technical complexity and feasibility were noted as challenges for future implementation.

Ultimately, the project demonstrates that ATAG can actively contribute to making repair more accessible for its user base. By empowering users with timely prompts, guided tools, and smart assistance, ATAG can shift its service model towards one that promotes user autonomy and supports product longevity. The findings and concepts presented in this report lay the groundwork for further development and integration of consumer-focused repair solutions in the company's service ecosystem.

ABSTRACT

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1. INTRODUCTION

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Problem statement
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This chapter serves as an introduction to the project. It provides background information and presents the problem statement. The assignment is formulated, including the research questions and approach. The project's scope is explained, and reasons are given for a specific product focus. Lastly, the company that was collaborated with is introduced.

1.1 Background

In the face of growing environmental concerns and unsustainable consumption patterns, repair is emerging as a powerful tool to reduce waste and extend the life of products. Repair is deeply intertwined with sustainability and the circular economy. The current linear economy is based on the 'take-make-waste' model, which is destructive and puts pressure on the planet (Ellen MacArthur Foundation 2013). In 2022, 62 million tonnes of e-waste were generated worldwide, 82% more than in 2010. Only 22.3% of this waste was properly recycled. The rest is left to fill up landfills or to become a pollution risk for humans, animals and the environment. Recycling met only 1% of the world's demand for rare metals, which are used extensively in electronic products. Moreover, while recycling is a great way to recover materials, making new products from these materials is still very energy-intensive (E-Waste Monitor, 2024). The best way to reduce the environmental impact of these electronic products is to use them for longer (Truttmann & Rechberger, 2006), and repairing is a great way toachieve just that

Promoting repair and prolonged use fits well with the circular economy. Transitioning to a circular economy is necessary to improve sustainability and protect natural resources. As the circular economy is an "*economic system based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/ distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations.*" (Kirchherr et al., 2017)

1.2 Problem statement

Although repairs are an effective way to extend product lifespan, many products that could be repaired are often replaced instead (Kirchherr et al. 2017). Despite this potential, consumers are often hesitant to engage in self-repair. This is not only because of technical limitations like products not being designed for repair, irreversible fasteners, lack of documentation and spare parts (van der Velden, 2021; Roskladka et al., 2023). Consumers also experience certain barriers that prevent them from doing so, including but not limited to perceived (lack of) skills & knowledge, lack of confidence, required time & effort and repair costs (Jaeger-Erben et al. 2021, Sonego et al. 2022, Terzioğlu 2020).

While theoretical research has identified barriers and motivators related to consumer repair behaviour, there is limited knowledge on practical solutions that leverage this understanding to encourage more frequent self-repairs. Current technological advancements focus primarily on making repairs easier through design and increasing product repairability, but often overlook how technology can influence consumer motivation and their perception of repairability (McLaren et al. 2020). This ability to motivate users is key as the repair depends on their willingness to put in the time and effort (Terzioğlu, 2021).

This project aims to develop a practical solution that increases the willingness to repair and encourages more frequent self-repairs by leveraging theoretical knowledge of repair influences in a real-world application.

1.3 Assignment

1.3.1 Research questions

To manage the project's complexity and keep it focused, a research question and several sub-questions were formulated.

How can willingness to repair be increased for (ATAG) dishwashers currently present in customers' households?

- Which intervention points in the consumer self-repair process of a dishwasher can be identified?
- What barriers and motivators do ATAG customers experience when considering to repair their broken dishwashers?
- What type of human-centred design interventions can effectively support and encourage ATAG customers to repair their dishwashers themselves?

1.3.2 Approach

To address the research questions, a human-centred, co-design-driven approach was adopted. This decision reflects the nature of the project, which focuses on understanding and influencing user behaviour, specifically the willingness of ATAG customers to repair their dishwashers. This project is rooted in real user experiences, motivations, and barriers. Therefore, it was important to base design decisions on insights gathered from the field.

Each research question called for a combination of qualitative and design research methods:

- Literature research was conducted to understand how willingness to repair could be increased. This explored existing theories on user behaviour, sustainability, and repair culture.
- Literature and field research were applied to uncover the barriers and motivators ATAG customers face when considering repair. Semi-structured interviews offered in-depth insight into ATAG's repair environment, and field research activities revealed insights about repair in real-life settings.
- Literature and field research were conducted to identify key intervention points in the repair journey. These methods helped map the consumer self-repair process and revealed intervention. The literature provided complementary frameworks and behavioural models to support and structure these findings.

Following the research phase, the insights were translated into design opportunities. Creative sessions, including brainstorming and ideation workshops, were used to generate a wide range of ideas. These concepts were then evaluated using Harris profiles in combination with qualitative reflection, ensuring a structured selection process. The chosen ideas were rapidly prototyped and tested through two iteration cycles. Ultimately, one final concept was developed and validated through user testing to assess its potential to increase users' willingness to repair.

This approach ensured that the final concept was grounded in real user needs, behaviour, and context.

1.4 Scope

This project focuses on motivating and involving consumers in the repair of their current dishwashers, rather than proposing changes to the product design itself. The decision to focus on existing machines is based on the need to encourage repair behaviour within the current landscape. Redesigning products to make them easier to repair is outside this project's scope, as it involves long-term manufacturing and design processes that cannot be influenced within this timeframe. Having to buy a new machine to make it easier to repair defeats the purpose of encouraging people to repair their own products. Repair is the exact thing that needs to be encouraged to keep products from being replaced.

The focus is on the human side of the repair process, aiming to reduce the psychological and practical barriers that prevent consumers from attempting repairs. The project aims to empower users by

making the idea of repair more accessible, achievable and rewarding. Factors beyond direct control, such as legislation, parts availability or systemic changes in product design, are excluded. Instead, the focus is on developing interventions that work within the existing context and encourage behaviour change, offering solutions that consumers can act on immediately.

1.4.1 Product focus

While all products should be repairable, it is impossible to focus on all product categories simultaneously in this project. This is especially true when considering that ATAG Benelux consists of 5 different brands, each with a wide range of products. Therefore, one category was chosen for which to develop a solution. In future endeavours, this specific solution could be generalised and applied to other product categories as well.

The reasoning for choosing the dishwashers stems from early research activities and discussions with ATAG service employees and company mentors.

Repair diversity
Dishwashers are complex machines containing water, electricity, and moving parts. Some repairs are difficult and risky and require almost complete dismantling of the machine. However, relatively simple repairs can be carried out while the dishwasher is still installed. This provides the opportunity to test the design in many different situations and repair complexities within a single product.

Figure 1. ATAG DW50 dishwasher

Sales
Dishwashers are the product category ATAG sells the most, accounting for almost 30% of total sales. This means most people can be reached when consumers repair this product more often.

Service calls
Apart from the most sold, 40% of all service calls are dishwasher repairs, which is a large percentage considering that dishwashers account for 30% of total sales. This further increases the number of consumers who can be reached.

Lifetime
Dishwashers tend to last a long time, which may increase consumers' motivation to repair one. Buying a new dishwasher is expensive, and if the dishwasher has a few more years before it needs to be replaced, then repairing a broken one is particularly worthwhile.

Product build-up
Dishwashers' functions are similar across models and brands. The main difference is the accessibility of the components. This makes it easier to generalise a solution that works across different types of dishwashers.

ATAG supplied a loan dishwasher to use for user tests and product evaluations. After consultation, a mid-range model was chosen, the DW 50 (Figure 1). This model is one of the most popular, and, unlike its more expensive counterpart, it has a plastic frame rather than a stainless steel one, making it much lighter and easier to transport.

Future solutions will be developed for this particular model for ease of testing, but potential solutions are expected to be quite transferable between different dishwasher models, as they do not differ much in design and functionality.

1.5 Client

This project is being carried out in collaboration with ATAG Benelux, the umbrella name for the Benelux subsidiary of the global multinational Hisense. This subsidiary consists of five brands: ATAG, Pelgrim, ETNA, Hisense, and ASKO. These brands mainly sell large built-in kitchen appliances such as ovens and refrigerators, but the product range also includes televisions and washing solutions. In this report, ATAG Benelux and its brands are referred to as "ATAG."

ATAG's large service department handles a wide range of repair jobs, from complex two-hour jobs to simple 15-minute fixes such as changing a lamp. However, sending out mechanics for both types of repair is (financially) resource-intensive, manpower-intensive, and time-consuming. Encouraging consumers to carry out basic repairs themselves could alleviate this burden, allowing professional mechanics to focus on more complex repairs that consumers are unable to carry out themselves.

By encouraging self-repair, ATAG can differentiate itself from competitors by providing in-depth repair assistance, promoting spare parts sales and enhancing its brand image. In addition, successful repair experiences can strengthen user-product attachment and foster brand loyalty, as consumers feel more invested in products they have repaired themselves (McLaren et al., 2020; Van Der Velden, 2021).

2.
ATAG SERVICE CONTEXT

The (self-)repair journey GSD, the ATAG mechanic repair platform

Error codes

Website repair help

Maintainlife.com, the parts webshop

To understand the challenges and opportunities in encouraging self-repair, it is important first to understand ATAG's current approach to repairs and servicing. This chapter provides an overview of the company's repair ecosystem, including how service repairs are handled and what platforms and resources ATAG's mechanics use to assist them in this process. Exploring ATAG's existing service-repair environment helps contextualise the findings from the literature research and later research activities. The information given in this chapter mainly comes from the field research activities described in Chapter 5 of this report.

2.1 The (self-)repair journey

When one of their dishwashers breaks, ATAG provides a service to get it working again. Figure 2 shows the full process from a broken dishwasher to a repaired dishwasher. This overview includes all the steps and stakeholders in this process.

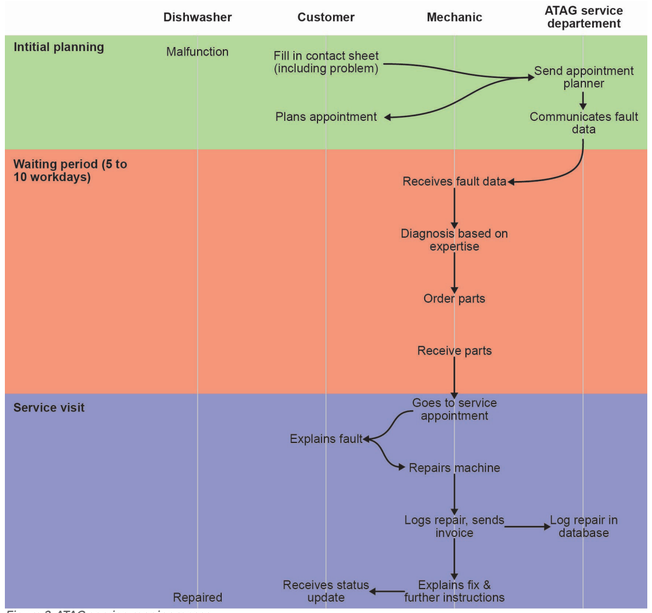


Figure 2. ATAG service repair process

Figure 2 displays the complexity and intercommunications within this repair process. However, this project does not deal with ATAG service repairs but self-repairs by ATAG consumers. To get an idea of what their self-repair process might look like, the previous visual was adapted to an ATAG consumer. Figure 3 shows a translation of the professional to a consumer situation. It does not show the current consumer repair situation, but rather represents an ideal consumer repair situation.

There are three things to note about this shift in repair responsibility:

1. The shift of repair tasks to the customer reduces direct interaction between consumers, service providers, and mechanics, decreasing the work ATAG must do for a repair to take place.
2. The role of the mechanic is also changing, as fault diagnosis, parts ordering, and repairs become the customer's responsibility. This shift changes the repair workflow, requiring more consumer independence.
3. However, ATAG can still provide support by maintaining control of the fault diagnosis tool and tracking spare parts orders. By logging faults and monitoring parts distribution, they can gain insight into common failures and customer needs, ensuring continued service quality even in a self-repair model.

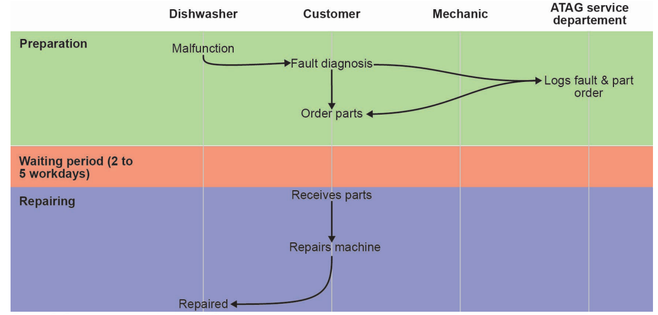


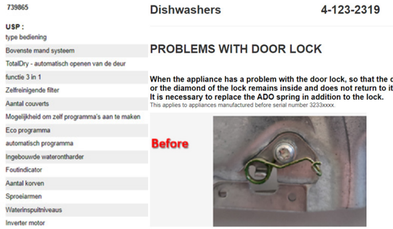
Figure 3. Customer repair in the ATAG service context

2.2 GSD, the ATAG mechanic repair platform

GSD is a platform used by ATAG and its mechanics for service visits. It contains parts lists, product manuals, service diagnostics, exploded views, wiring diagrams, service instructions, technical information, and product information. These are all the types of documents mechanics might need to look up during a visit.

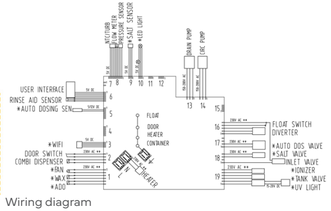
As part of ATAG's compliance with the right to repair legislation, they have started uploading repair instructions for washing machines, with other machines to follow. Some of these instructions are already available in GSD, and some are custom-made for consumers. At this point, they are only available to ATAG employees and not yet to the general public. A few examples of these types of documents can be found below (Figure 4).

Product information



Service instruction

Troubleshooting diagram



Wiring diagram

Figure 4. Examples of ATAG repair files

2.3 Error codes

ATAG's dishwashers have an error code system for common faults a dishwasher might experience. Users can find the table explaining the error code in the physical manual they get with the dishwasher. However, the error codes are also available online. Part of this table is shown in Figure 5. The table describes the error code and actions the user can take to remedy this error. However, these actions are very minimal, and the users are referred to the closest service point very quickly.

F11	Fout waterafvoer	Zie "Er blijft water in de vaatwasser achter" onder "Probleem" in de onderstaande tabel. Als het probleem zich blijft voordoen, neemt u contact op met het dichtstbijzijnde servicedienst.
F12	Fout waterinlaat	Controleer of de waterkraan open staat. Controleer of het buiten-filter op de toevoerslang niet geblokkeerd is. Raadpleeg *De toe-voerslang ontstoppen* in hoofdstuk *Onderhoud en reiniging*. Als het probleem aanhoudt, dient u contact op te nemen met de ser-vicedienst.
F40	Lekkage inlaatklep	Draai de waterkraan dicht en neem contact op met de dichtstbij-zijnde servicedienst.

Figure 5. Example DW50 error codes

Consistent with Pozo Arcos et al. (2022) manual analysis, the manual for the DW50 also does not offer guidance in case of a common fault and refers to a service centre. Furthermore, Pozo Arcos et al. (2022) mention that guidance is provided in case of overdue maintenance, but guidance is missing in case of malfunction outside of that realm. While this makes the fault diagnosis process safer for users, it is also very limiting. In a world where users are expected to self-repair, it is important to provide them with a fault diagnosis that not only guides them in case of overdue maintenance, but also in case of any malfunction. In order to do that, Pozo Arcos et al. (2022) composed fault diagnosis guidelines (Table 1), which will provide useful information for developing a fault diagnosis solution.

Table 1: Fault diagnosis guidelines

Actions	Goals
· Relate symptoms to components · Retrieve history of usage/repairs · Gather product information	· Determine defective component(s) & Isolation actions

After the manual tells consumers they should contact the nearest service provider, they will quickly end up at the ATAG website.

2.4 Website repair help

The ATAG website also contains some help in case of a malfunctioning appliance, ranging from help with malfunctions to documentation and arranging service visits (figure 6). While the website provides users with useful information, at this moment, it cannot be fully used to help with self-repairs. Meaning additional help pages are needed for consumers to get help in case of a self-repair.

The problems & malfunctions section contains, for example, an FAQ, common problems and basic information regarding problem solving (relating to settings and maintenance, rather than broken parts). Again, not very useful if you want to do a full repair yourself, because this doesn't give all the information and help you need for a full repair. It is a nice start, and since there is already digital space reserved for it, this section of the website could easily be expanded to facilitate more in-depth repair help.

Figure 6. Subjects ATAG website provides help for.

However, this website still lacks information on how and where spare parts can be bought. For that, ATAG has a separate platform called maintainlife.com.

2.5 Maintainlife.com, the parts web shop

ATAG recently launched maintainlife.com, a web shop where spare parts and accessories for all ATAG appliances can be bought (Figure 7). While for now, they only sell basic parts, like racks and cutlery baskets for dishwashers, the assortment is planned to expand with actual spare parts in the future. Users can look up the parts they need by type of appliance, brand, specific part number, or article number of the machine.

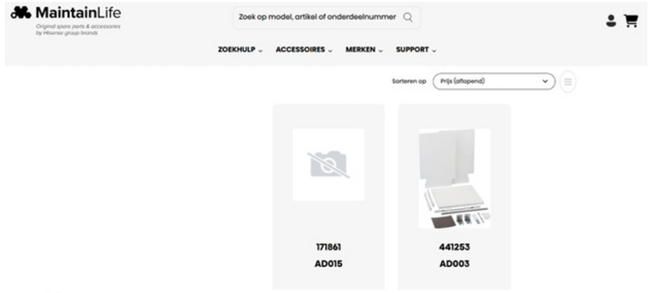


Figure 7. Dishwasher parts page on maintainlife.com

2.6 Conclusion

This chapter outlines ATAG's current repair landscape, providing important context for understanding the potential role of self-repair in the future. While ATAG has a well-established professional repair process supported by internal tools like GSD and error code systems, the infrastructure for consumer-led self-repair remains limited.

The shift toward self-repair introduces a new dynamic, where consumers take on responsibilities traditionally handled by mechanics, such as fault diagnosis and part replacement. Although this reduces ATAG's operational load, it also necessitates more robust support to enable users to navigate the process independently. Platforms like maintainlife.com and the ATAG website provide a foundation for this, but currently fall short in offering comprehensive self-repair guidance. The solution should utilise these existing platforms to facilitate the transition as smoothly as possible and make optimal use of currently available resources.

There are opportunities for ATAG to expand its existing digital ecosystem by enhancing the repair content available to consumers, integrating fault diagnosis tools, and improving access to spare parts. These developments would not only support a growing trend towards self-repair but also align with right-to-repair regulations and sustainability goals. As more smart appliances enter the market, ATAG is well-positioned to build a future-proof system that empowers its customers while maintaining high service standards.

3. SELF-REPAIR PROCESS & BEHAVIOURAL INSIGHTS

What is repair
Consumer self-repair

Understanding consumer self-repair is essential for developing effective interventions to encourage dishwasher owners to repair their appliances. This chapter explores two key research questions:
1. Which intervention points in the consumer self-repair process of a dishwasher can be identified? and 2. What barriers and motivators do ATAG customers experience when considering repairing their broken dishwashers?

This chapter is divided into two sections to answer these questions. The first section, 'What is repair?', provides an overview of the repair process. The second section, 'Consumer self-repair,' examines the factors that influence whether consumers choose to repair their dishwashers.

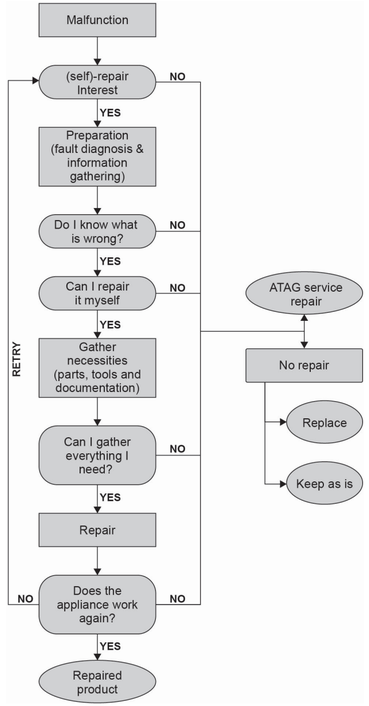


Figure 8. The repair process, adapted from Svensson-Hoglund et al. (2023)

3.1 What is repair?

This section dives deeper into what repair is, what the repair process entails, and which actions need to be performed in order to repair a product from the consumer's perspective. A specific repair process for this project is defined, and guidelines for a successful fault diagnosis process are listed. Lastly, the influence of product categories is researched, including which category dishwashers fall under.

3.1.1 The repair process

It is important to first identify what intervention moments are available to determine where to intervene with a design solution. Therefore, an individual repair process was mapped out (Figure 8). This process was adapted from the repair process defined by Svensson-Hoglund et al. (2023).

As noted by Jaeger-Erben et al. (2021) and Russell et al. (2022), to repair something depends on multiple consecutive decisions actually to pursue the repair. As represented in the visual, the user can decide at multiple moments in the process to quit and replace the product or have ATAG service come over and repair the broken appliance.

From this repair process, three touchpoints can be defined: the preparation, gathering of necessities, and the actual repair.

In the **preparation**, information about the machine and the malfunction is gathered. This information is then used to assess the problem and will hopefully lead to a successful fault diagnosis. After the fault diagnosis, the user can gauge whether they think they can repair the problem themselves or if they need someone else to do it.
After **gathering the necessities**, it is clear what needs to be repaired. This repair probably needs a spare part, documentation, and tools (or other materials in case of a visual defect). During this phase, these materials are collected so everything is ready for the actual repair. If the user is able to successfully gather all the needed materials, they are more likely to do the actual repair.
During **the actual repair**, the previously collected materials are used. Tools and spare parts are already optimised and just need to work. So, the aspect to focus on here is the instructions. Repair instructions can be made in many different ways (videos, pictures, abstracted drawings). The important thing is that these instructions are well understood by the broadest possible audience.

3.1.2 The diagnosis process

Pozo Arcos et al. (2020) describe the fault diagnosis process for household appliances (figure 9), which is a crucial step in repairing dishwashers. As accurate fault diagnosis is directly linked to consumers' ability to complete a repair, this process will be considered when designing an intervention for this project. While diagnosing faults is relatively straightforward for experts, it poses a significant challenge for individuals unfamiliar with a specific appliance's repair process or inner workings. This difficulty is a key barrier to self-repair, particularly for dishwashers, which contain multiple essential components that could contribute to a malfunction.

Most dishwashers use an error code system, where the display provides a code that can be referenced in the user manual. However, these codes typically indicate the symptom of the issue rather than its underlying cause. For instance, in ATAG's case, error code F11 indicates an issue with the dishwasher's drainage system, but this may indicate a malfunctioning drain pump, a blockage in the drain pipe, or another underlying problem. Identifying the actual cause still requires additional troubleshooting by the user, which can discourage self-repair (Van den Berge et al., 2023). By providing better guidance through the step-by-step fault diagnosis process, consumers may feel more confident in identifying the root cause of an issue, increasing the likelihood that they will attempt and complete a successful repair.

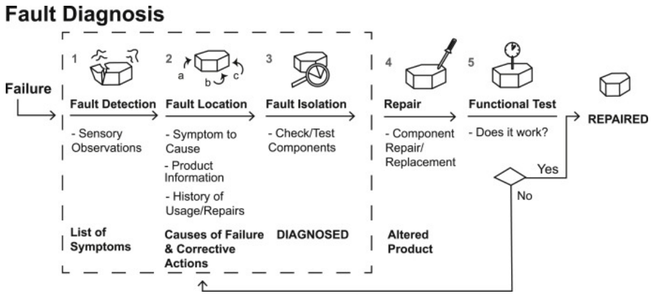


Fig 9. Conceptual framework of the process of fault diagnosis (Pozo Arcos et al., 2021)

3.1.3 Product categories

Understanding how consumers perceive their products is essential in determining their willingness to repair them. The way a product is valued, whether as a practical necessity, a long-term investment, or a replaceable item, can have a major impact on repair decisions.

According to Cox et al. (2013), products can be divided into three categories: workhorse, investment, and up-to-date. Products don't necessarily belong to only one category and can belong to different categories for different people. This also means that some products can belong in multiple categories for the same person in different situations.
Workhorse products need to be reliable and are almost exclusively used for the benefits and usefulness they provide to the user. They are typically used for many years and only discarded when broken. This class mostly consists of large appliances and large items of furniture.
Up-to-date products are on the opposite side of the spectrum. They are easily updated for style or technology and often driven by fashion or impulse. They play a key role in self- and social identity and are frequently replaced. This category includes clothes, mobile phones, technological gadgets, and household items like cushions, curtains, and lamps.
Investment products are considered "special" and worth the effort to purchase and maintain. They are typically expensive,

with value being subjective, and often have emotional significance, such as gifts or long-awaited purchases. This category includes high-quality electronics, large furniture and major appliances.

According to this definition, dishwashers can belong in the workhorse category. An argument could be made for dishwashers to be put in the investment category, but since the value of a dishwasher is so much based on the utilitarian value it provides to the user, 'workhorse' is a better fit. Positively, for workhorses, repair is usually considered; however, this choice is often based on uncertain estimations of additional life a repair will provide, how much the repair will cost and how inconvenient it will be to accomplish for the user (Cox et al. 2013).

Since a customer's choice to repair is based on uncertain estimations, it might be valuable to ensure the customer does not have to make estimations themselves, but that these are done by an expert, in this case, ATAG. They can create awareness amongst their customers that repair does not have to cost much money and that it will not be very inconvenient.

3.1.4 Conclusion

The decision to repair is not made in a single moment; rather, it is an ongoing process influenced by various factors at each stage. Consequently, effective interventions must support and guide users throughout the repair journey. From identifying the problem to completing the repair, users need assistance in overcoming both motivational and practical barriers.

Fault diagnosis is a major hurdle, as many consumers struggle with unclear guidance. While dishwashers provide fault codes, these codes indicate symptoms rather than root causes, leaving users uncertain about how to proceed. Existing manuals often fail to bridge this gap, highlighting the need for better diagnostic support to enhance self-repair success.

Dishwashers can be considered workhorse products, meaning they tend to be valued for their functionality rather than style or status. This makes them more likely candidates for repair, as consumers prioritise longevity over frequent replacement. By identifying key intervention points and addressing the challenges users face at each stage, a well-designed solution can increase self-repair rates and make the process more accessible and manageable.

3.2 Consumer self-repair

This section zooms in on consumers' relationship with repair. It describes the influences, both barriers and motivators, they experience, and research is done on how consumers can be motivated to make the decision to self-repair based on planned behaviour and the Fogg behaviour model.

3.2.1 Repair influences

To answer the question: What barriers and motivators do ATAG customers experience when considering to repair their own broken dishwashers? Three recent papers that provide a detailed overview of repair influences were analysed, namely Jaeger-Erben et al. (2021), Sonego et al. (2022), & Terzioğlu (2020). Before knowing which aspects influence ATAG consumers, it is important to know which self-repair barriers and motivators exist in general. Not all influences are relevant to this project's specific context; therefore, all influences were classified into three categories:

1. The factor cannot be influenced within the context of this project.
2. The factor is influential within ATAG's context, but it is outside the scope of this project.
3. The factor is relevant within the context of this project.

This complete overview can be found in table 7 in Appendix I on page 98.

To create a more manageable overview, the relevant influences from the initial list (in green) were extracted and simplified. In the initial overview (appendix I), the influencers are all categorised into specific dimensions; these dimensions were removed. This resulted in a list of individual influences. Similar influences were then grouped together, and overlapping ones were combined or removed. Next, similar influences were merged and given a new name that represents a broader influence. This process resulted in a greatly reduced list of influences (table 2, next page). This table presents all key influences, along with a brief explanation of how each one affects the likelihood of users performing self-repairs on ATAG dishwashers. The influences are listed in no particular order.

Some design-specific requirements were formulated (page 29) to ensure that these influences are considered during the design of the intervention. These requirements aim to enhance the motivating influences and to overcome the barrier influences.

Table 2: Context-relevant repair influences

Influence	Influence on the self repair of dishwashers
Sociodemographic factors	Age plays a role in repair behaviour. Younger, more technologically adept people are more likely to seek online help for repairs. On the other hand, older individuals often have a stronger repair mindset and may be more inclined to fix appliances themselves.
Lack of material, diagnosis help & instructions	The complexity of dishwashers makes repairs challenging. Unlike more straight-forward household items, dishwashers have multiple components and potential failure points, making fault diagnosis difficult. Since most users know little about dishwasher work, clear instructions are necessary, even for minor fixes.
Required time & effort	Repairing a dishwasher already requires significant time and effort. The effort needed for fault diagnosis, gathering parts and tools, and following instructions should be minimized to encourage self-repair. The process should be as quick and straightforward as possible.
Cost of repair	The cost of dishwashers influences repair decisions in conflicting ways. Their high price encourages repair over replacement, but at the same time, expensive spare parts can make replacement seem like the better option. Additionally, because dishwashers are costly, some users may hesitate to attempt self-repair for fear of causing further damage, making professional repair or replacement the safer choice.
(Perceived) lack of skill	Unlike other household appliances, dishwashers are fully enclosed, making it difficult for users to understand how they function or what might be wrong. The inability to see the internal components adds another layer of uncertainty to the repair process.
Lack of confidence	Confidence in self-repair is closely linked to perceived skill level. Users who believe they lack the necessary skills are also likely to doubt their ability to complete a repair successfully. However, it may be possible to boost confidence without directly improving skills, for example, through clear guidance and reassurance.
Repair enjoyment	Repair experiences vary from person to person; some find it enjoyable, while others consider it tedious. The process can be made more appealing by reducing frustrating or time-consuming steps. Additionally, an engaging and well-designed repair solution can increase enjoyment, making repair a more positive experience overall.
Perceived repair efficacy	When a dishwasher is correctly diagnosed, the repair process is often straightforward, typically involving the replacement of one or two components. Once repaired, the dishwasher usually functions as well as before for a long time. However, many users are unaware of this, which may discourage them from attempting repairs in the first place.
Product attachment	Product attachment increases the likelihood of repair. Since dishwashers generally do not evoke a strong emotional attachment, efforts should be made to create a sense of connection before the appliance breaks. This can help ensure that users are more willing to repair rather than replace when a malfunction occurs.
Environmental concern	Extending the lifespan of a dishwasher is beneficial for the environment. These appliances are large, complex, and made of various materials, making recycling difficult. Additionally, they require significant energy and resources to manufacture and recycle. Repairing and using a dishwasher for as long as possible is the more sustainable option, especially since newer models often do not offer significant energy or water efficiency improvements.

3.2.2 Motivating future self-repairers

Knowing what barriers and motivators potential self-repairers experience is important within the context of this project, but it is also important to know what systems lie underneath the motivations. How does behaviour come into being? What influences lead to a certain behaviour? And how can people be stimulated to act on certain desired behaviours?

3.2.2.1 Planned behaviour

In the theory of planned behaviour, intentions to execute a certain behaviour in an individual can be predicted by evaluating the attitude toward the behaviour, the subjective norm and the perceived behaviour control (Ajzen 1991) (Figure 10).

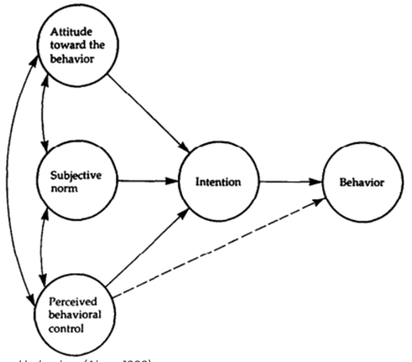


Fig 10. Theory of planned behaviour (Ajzen, 1999).

Attitude relates to whether an individual thinks a certain action is favourable or unfavourable to do for them. With regards to this project, it consists of whether an ATAG consumer thinks executing a self-repair is a good thing to do. If they do, they are more likely to do it.

Subjective norms are the individual beliefs about what the general public would think about executing a certain action. So, in this case, what users of ATAG products think, society at large thinks about them repairing their own dishwashers.

Perceived behavioural control refers to how hard an individual thinks it is to execute a certain action. For example, within the context of this project, the consumer thinks they are able to repair a broken dishwasher.

While not indicated in the visual itself, the paper explains that increasing one of these aspects will have a positive effect on the intention to execute a certain behaviour and, in turn, executing the behaviour itself. Therefore, increasing one of or all three of these aspects is essential to increasing the likelihood of consumers executing self-repairs on their dishwashers.

To increase the user's **attitude**, they will need to think more favourably about (self-)repairs. Users will be unable to think more favourably about repairs if they are unfamiliar with the benefits of repair. Therefore, it is important to make the users aware of the benefits of repair, as defined in a previous chapter. To encourage self-repair over ATAG service-repair, the additional benefits of self-repair, like the reduced wait time and lower monetary costs, might be leveraged.

While **subjective norms** refer to society's broader perceptions and may seem difficult to influence, they can still be shaped through targeted interventions. For example, displaying indicators such as '80% of customers successfully repaired this product' can create a sense of social proof, making the repair feel more achievable and normal. Additionally, campaigns, such

as government initiatives highlighting changing behaviours ('Everyone is doing their part'), can reinforce the idea that repairing instead of replacing is becoming the norm. ATAG is not a government agency, but could employ the same strategies on a smaller scale. Trying to influence their consumers and creating a consumer base in which repairing is the norm. Although shifting public opinion takes time, these strategies can support adopting the proposed solution by gradually increasing the perception that repair is a common and expected behaviour.

Perceived behavioural control: The user's ability does not necessarily need to be increased, although it might help. Rather users need to perceive themselves as being able to execute the repair. This can be done by enabling the users to deal with a repair's (perceived) complexity and making the experience convenient for them.

Furthermore, Ajzen (1985) mentions that the decision to execute a certain behaviour also relies on certain non-motivational factors, including time, money, skills, and the cooperation of others, which match the factors discussed in the previous chapter.

Ajzen emphasises that a person's environment and circumstances must support the intended behaviour for them to follow through with it. This aligns with Jaeger-Erben et al. (2020), who highlight that repair becomes more challenging in a society where it is no longer the norm. This suggests that motivating consumers to repair their appliances requires more than just increasing their intrinsic motivation; ATAG should also create an environment that makes repair easy and accessible. ATAG can help remove barriers to self-repair and encourage more customers to engage in the process by providing the necessary support and resources.

3.2.3 The Fogg behaviour model

Fogg (2009) describes a model that shows how a target behaviour can be achieved (Figure 11). This model has three elements: 1. Motivation; 2. Ability; 3. Triggers. In short, triggers lead to the target behaviour when ability and motivation are adequately high (passed the threshold line). Important to note is that motivation and ability can trade off. Someone with low motivation but high ability might be just as likely to execute a certain behaviour as someone with high motivation and low ability.

As we can see in the model, increasing either motivation or ability will increase the chance of a successful trigger; however, increasing both will have an even greater chance of a successful trigger.

In the case of dishwasher self-repair, a model like the above can be drawn up for every decision moment in the journey (section 3.1.1). Between each moment, be a different ratio between ability and motivation, making it important to target the right ones with the right amount and add a well-timed trigger so that the consumers reach the targeted behaviour every time.

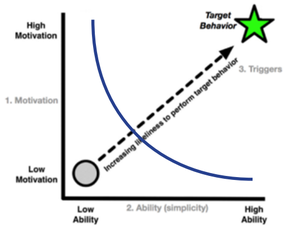


Figure 11. Fogg behaviour model (Fogg, 2009)

Furthermore, Fogg (2019) adds, "One of the best ways to get people to do a behavior in the long term is to build their confidence and ability through baby steps." Following this advice, the design needs to offer there might different repair steps in small consecutive steps, preferably in increasing difficulty, to increase the chance of the targeted behaviour, such as self-repairing a broken dishwasher, being executed.

3.2.4 Consumer self-repair conclusion

Understanding and addressing the various influences on consumer self-repair is essential for designing an effective intervention. This design considers key influences on repair and works to reduce barriers such as lack of confidence, perceived difficulty, and lack of resources, while harnessing motivators like the enjoyment of repair and environmental concern. In doing so, the intervention increases the likelihood that consumers will attempt and successfully complete repairs.

The approach is based on Planned Behaviour Theory, ensuring that all three key factors - attitudes towards repair, subjective norms, and perceived behavioural control - are strengthened. Consumers are made aware of the benefits of repair, shown that others have successfully engaged in self-repair, and provided with the necessary resources to feel capable of doing it themselves.

The Fogg Behavioural Model is also applied, focusing on increasing both capability and motivation at the right moments in the repair process. By breaking the repair journey into incremental, manageable steps, the design helps consumers build confidence, reduce perceived difficulty, and increase the likelihood of repair success.

3.3 Conclusion

In this chapter, the literature research was conducted to answer the research questions 1. Which intervention points in the consumer self-repair process of a dishwasher can be identified? and 2. What barriers and motivators do ATAG customers experience when considering repairing their broken dishwashers? The first question was answered with a self-repair visual on the self-repair process of consumers (page 22). The second question can be answered with the self-repair influences table on page 26.

Next to the research questions, a design vision can be concluded from the preceding research:
The intervention should create an accessible, structured, and confidence-building repair experience. This means:

1. Guided Repair Process: This involves providing step-by-step assistance tailored to the user's needs throughout the self-repair process.
2. Motivational Reinforcement: Leveraging the multiple aspects that lead consumers to a certain decision to increase the chance of self-repair
3. Incremental Learning & Confidence Building: Designing the experience so users gradually progress step-by-step and gain trust in their abilities.
4. Seamless Integration: Ensure that ATAG plays an active role in facilitating repair through communication and practical support.

Focusing on both the practical aspects of repair and the psychological barriers consumers face can make self-repair of ATAG dishwashers accessible to the regular consumer.

Furthermore, several design requirements were formulated from the literature. These can be found below.

- Use of the design involves a minimal learning process
- The interaction with the design follows the formulated interaction qualities
- Convenient
- Solutions for common practical challenges, such as getting required tools, access to repair manuals & instructions, and ordering replacement parts are integrated in the design.
- The design highlights the financial and practical benefits of self-repair to encourage dishwasher owners to self-repair.
- The design leverages the longevity of dishwashers to reduce the replacement mindset
- The design communicates a repair summary, estimated cost, and repair time range after the fault diagnosis and before the actual repair.
- The design makes consumers aware of the general repair efficacy (effectiveness & success of a repair), and after fault diagnosis, they are made aware of the specific repair efficacy

- The design ensures users will feel that their skills are adequate before and during the repair.
- The design guides users in identifying the issue accurately, without the need for external assistance.
- The design provides clear, structured repair instructions.
- The designed fault diagnosis and instruction solution are interesting to use.

4.

INSIGHTS FROM THE ATAG SERVICE CONTEXT

Interviews with ATAG service employees

Washing machine training

Ride-along day

Dishwasher analysis

Various research activities, such as interviews with professionals, attending mechanic training, a ride-along day with an ATAG mechanic, and an in-depth dishwasher analysis with a mechanic trainer allowed for a deeper understanding of the context. These activities were aimed at exploring the products that need to be repaired often, the difficulty of different repairs, what repair help ATAG already provides, and what type of documentation the mechanics use.

4.1 Interviews with ATAG service employees

The interviews with ATAG service employees' primary objective was learning about the service mechanic context. What does their training consist of, and what does a typical day for an ATAG service mechanic look like? It also researched what opportunities these professionals envisioned for increasing the self-repairs among their consumers. While it wasn't a primary objective initially, these interviews also helped arrange the following research activities: washing machine training, ride-along and in-depth dishwasher analysis.

Three semi-structured interviews were conducted with three employees with different functions within the service department at ATAG Benelux. These interviews were done either in person or online and took about 45 minutes each. The interviews were recorded and transcribed using Microsoft Teams. Afterwards, the transcriptions were analysed by picking relevant quotes and grouping them by subject matter.

4.1.1 Observations

Two of the interviewees expressed scepticism when asked if they thought ATAG consumers would be able to repair their broken appliances themselves. Concerns ranged from a lack of trust in consumers' ability and willingness to general safety concerns. They also mentioned that a new repair mechanic is trained for 2 years before being able to repair all appliances.

The interviewees agreed with a finding from the literature. They stated that customers would probably be able to execute many repairs themselves, provided that they were guided very well during the whole repair process. Important to note is that the repair professionals were confident that consumers would be able to execute repairs with this proper guidance.

All interviewed participants emphasised that there is a big difference in difficulty between the different repairs. Varying from repairs that can be done by everyone to repairs that should only be done by experts. This insight led to the dishwasher analysis and accompanying repair table on page 35.

4.1.2 Insights from interviews with ATAG service employees

Consumers need proper guidance

While consumers are expected to carry out repairs themselves, they cannot be expected to know instinctively how to do it. They need clear information about the repair process, including necessary safety precautions and step-by-step instructions. Their knowledge does not need to match that of a professional mechanic, but they must have enough understanding to complete the repair safely and effectively. This is consistent with the literature, which emphasises the importance of guiding users through each stage of the repair process.

Barriers identified in both literature and interviews

Interviewees mentioned barriers for consumers that match the influences found in the literature. In particular, the time and effort required to complete a repair and a (perceived) lack of skills were highlighted as key barriers. These factors may discourage consumers from attempting to repair themselves, reinforcing the need for interventions that reduce the effort and build confidence in their ability to succeed.

4.2 Washing machine training

To gain a better understanding of the repair work that ATAG's service engineers have to carry out, and what the learning process for ATAG's mechanics looks like, a new employee's training morning was attended. The new employee in question already had more than 25 years' experience repairing domestic appliances. As a result, his training would only take a few weeks to learn the appliance-specific differences, as opposed to the 2 years it would normally take to train a new repair mechanic.

During the morning, the repair process was observed, and questions were asked. No particular method was used to analyse the written material, as the notes were concise.

At this point in the research, the decision to focus on dishwashers had not yet been made; therefore, the machine being repaired was a washing machine.

4.2.1 Observations

The morning started with a short presentation on the theory, safety mechanisms, reasons for a particular assembly and why certain components are used in the washing machines. Tips and practical experience were also shared. The trainee was then guided through a washing machine repair. Replacing the main drum bearings. This is arguably the most difficult repair, requiring almost the entire washing machine to be taken apart. After the repair, a short debriefing was held, and the process for this machine was completed.

4.2.2 Insights from washing machine training

To learn how to repair appliances, even experienced repairmen have to follow training and are guided through the most difficult repairs to make sure they are doing it right. This shows that there is a big gap in knowledge between laypeople and professional ATAG mechanics. This gap is not needed to be bridged completely since most repairs don't require the full expertise a professional mechanic has. It is also undesirable for consumers to reach the same level of repair expertise, since they don't need to troubleshoot and repair all possible problems. Additionally, because of this training, the mechanics are able to do complete repairs that consumers cannot be expected to execute.

A few insights relate to practical tips when executing a repair, which proved useful in the eventual testing and conceptualisation of the solution. These tips are overviewed in Appendix II.

4.3 Ride-along day

To gain an understanding of the types of repairs carried out by service engineers and the environments in which they take place. A ride-along day with an ATAG service engineer was arranged.

A full day was spent with an ATAG service mechanic to do this. Seven customers were visited, and appliances repaired included dishwashers, ovens, an extractor hood, and a gas stovetop. Repairs ranged from short and simple to longer, more difficult repairs that required almost the entire appliance to be dismantled. During the day, the mechanic explained everything he was doing, from the repairs to logging all activities and payments, and I observed and asked questions.

4.3.1 Observations

For any repair, the power plug must always be disconnected; in some cases, water hoses also need to be detached. However, these hoses are often hidden behind kitchen cabinets, which can make them difficult to locate, especially for customers who are unfamiliar with how their kitchen was installed.

Fault diagnosis is typically straightforward for mechanics. Both the mechanic and other service professionals mentioned that in 90% of cases, they can immediately identify the issue and determine the necessary repair. If the problem is not what they thought it was, they can easily consult their manager or available documentation for help.

Throughout the day, a mix of renters and homeowners required service. In some rental properties, repair costs are covered by the landlord as part of the rent, meaning the service bill goes directly to them. While this setup appeared common during this observation, it is likely overrepresented due to a confirmation bias, since renters with included maintenance are more likely to call for repairs. In contrast, those responsible for their own repair costs may attempt to fix issues themselves, making them less visible in this setting.

4.3.2 Ride-along day insights

The repair does not begin with dismantling the appliance; certain preparations are required before the repair can begin. These can include disconnecting hoses and power cables, gathering the right tools, clearing the work area, and reviewing safety precautions to ensure a smooth and safe repair process.

Unlike professional mechanics, customers cannot access a supervisor or other additional help for troubleshooting assistance. They also don't have the expertise to diagnose independently. Therefore, a clear and structured fault diagnosis system is essential to help them accurately identify the faulty component without needing external guidance.

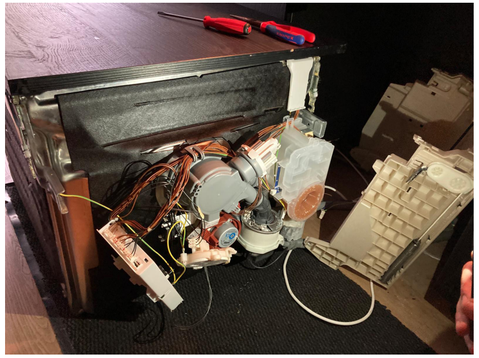


Figure 12. Dishwasher being repaired at a client's home

Customers living in rented apartments, including appliances, are less inclined to attempt self-repair as there is no direct financial benefit to them. Additionally, the risk of being held liable for any damage caused by an attempted repair further discourages these customers. This highlights machine ownership as an important factor in determining a customer's willingness to engage in self-repair.

4.4 Dishwasher analysis

This chapter explores the range and complexity of dishwasher repairs that are commonly carried out. It identifies which repairs are suitable for users to perform themselves and which are better left to professional service. This analysis also provided a deeper understanding of how a dishwasher functions, which proved valuable during both the ideation and validation phases of the project.

An ATAG repair expert explained a specific machine. He showed how it's (dis)assembled, explained how it works and what different components do. He also explained all the possible components that might need to be repaired, and we discussed which repairs consumers could do at home.

4.4.1 Dishwasher analysis observations

Apart from the appliance-specific repair tips, which are summarised in Appendix II, the findings consist of a comprehensible list of possible repairs that dishwashers may need, categorised by the 'side' of the dishwasher on which they need to be carried out. These are summarised in Table 3.1 - 3.3 (next page). With the help of an ATAG repair expert, three different levels of repair difficulty were identified:

1. Easy repairs that anyone can do with the right guidance.
2. Intermediate repairs that most people can do with the right guidance.
3. Difficult repairs, which should be left to professional mechanics.

These three levels have been determined based on several criteria: accessibility, type and quantity of fasteners, type of tool required, and risk to machine operation.

Easy repairs (16%) are all accessible through the dishwasher's front door and don't require any covers to be removed. These components don't need to be unscrewed and are secured with either twist-off caps or snap-fits that only require a screwdriver to pry open. Although all components are essential to the dishwasher's proper functioning, if one of them is not repaired correctly, the dishwasher won't break down immediately.

Intermediate repairs (80%) are a little more difficult to access, either by removing the plinth and a panel or moving the dishwasher about 15 cm forward. In both cases, the water inlet and outlet hoses can remain connected. All of these repairs involve undoing screws and snap fits The door and front repairs require the panelling to be replaced in a specific way.

Difficult repairs (4%) require the dishwasher to be completely removed from the kitchen block and the water supply and drainage hoses disconnected. These components are critical and could damage the rest of the machine if handled incorrectly. Some of the repairs require special tools that, in the worst case, are not available to the average consumer and, in the best case, are available but expensive.

To get the repair percentages, the service data of the DW50 dishwasher platform, and its variants were analysed. The data consisted of all service repairs done for the platform in 2022, 2023 and 2024. Specific component repairs and replacements were taken into account. Important to note is that this type of dishwasher has a known problem with its supply hose, which can cause a short circuit, destroying the main PCB, and warranting a replacement. Omitting the main PCB from the data results in the following percentages:

Easy repairs	31%
Intermediate repairs	62%,
Difficult repairs	7%.

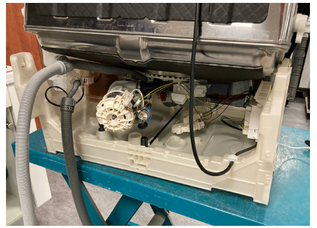


Figure 13. Opened backside of dishwasher

Table 3.1: Easy dishwasher component repairs

	Easy repairs			
	Component	Type of repair	Fasteners	Needed tools
Inside	All components in the inside can be accessed by opening the dishwasher door.			
	Rails	Replacement	Snap fits	None
	Wheels	Replacement	Snap fits	Prying screwdriver
	Guides	Replacement	Snap fits	None
	Spray arm	Replacement or cleaning	Screw cap	None
	Sieve	Replacement or cleaning	Twist cap	None
	Drain pump chamber	Cleaning	n/a	None
	Anti-slurping cap	Replacement or cleaning	Snap fits	None
	Salt reservoir lid seal	Replacement	Screw cap	Prying screwdriver
	Salt reservoir lid	Replacement	Screw cap	None
	Basket and attachments	Replacement	Snap fits	Prying screwdriver
	Door rubber	Replacement	Snap fits	None
	Riser pipe	Replacement or cleaning	Snap fits	None

Table 3.2: Intermediate dishwasher component repairs

	Intermediate repairs			
	Component	Type of repair	Fasteners	Needed tools
Door	For all door repairs, the decorative kitchen cabinet plate needs to be removed. After that the inside of the door can be accessed up by removing the plastic and the metal cover attached with eight screws.			
	Door PCB	Replacement	Screws	Torx 20
	Door lock	Replacement	Screws	Torx 20
	Soap dish	Replacement	Snap fits	Torx 20 + prying screwdriver
Front	The front can be accessed by detaching the skirting board after which a panel below the door attached with four screws can be removed.			
	Drain pump	Replacement or cleaning	Twist cap & snap fits	Torx 20
	Main PCB	Replacement	Snap fits	Torx 20 + prying screwdriver
Side	The side can be accessed by detaching the dishwasher from the kitchen block and pulling it forward about 15 cm. The front feet might have to be adjusted to allow the machine to be pulled out.			
	Door rope	Replacement or reattachment	Hook & eye	None
	Door	Replacement	Plastic clip	None
	Door hinge	Replacement	Plastic clip & screws	Torx 20 screwdriver

Table 3.3: Difficult dishwasher component repairs

	Difficult repairs			
	Component	Type of repair	Fasteners	Needed tools
Back	After building the dishwasher out, the back can be accessed by removing a panel at the bottom attached with four screws. To increase accessibility two screws on the side can be removed which allows the machine to be tilted forward and locked in place with a screwdriver.			
	Supply hose	Replacement	Belt clamp	Torx 20 + Adjustable-joint pliers
	Drain hose	Replacement	Belt clamp	Torx 20 + Adjustable-joint pliers
	Murkiness sensor	Replacement	Twist cap	Torx 20
	Pressure regulator	Replacement	Twist cap	Torx 20
	Washing pump + heating element	Replacement	Belt clamp & snap fits	Torx 20 + special belt clamp pliers
	Diverter valve	Replacement	Snap fits	Torx 20 + Prying screwdriver
	Salt reservoir	Replacement	Snap fits	Torx 20 + Prying screwdriver
	Labyrinth	Replacement	Screws & snap fits	Torx 20 + Prying screwdriver

Based on the table, the most challenging intermediate repair was selected to test the final concept: replacing the soap dispenser. In this particular dishwasher model, the dispenser is located in the door and requires the removal of various screw sizes, which must be reassembled in the correct positions. Additionally, the process involves disengaging snap-fits that can be difficult to release.

4.5 Conclusion

Multiple factors influence effective consumer self-repair of dishwashers, including knowledge gaps, effort barriers, and varying kitchen setups. While consumers are expected to handle repairs themselves, they need clear guidance on safety and step-by-step instructions. Unlike professional mechanics, who undergo training and can rely on supervisors for troubleshooting, consumers lack structured support and must be temporarily equipped with the necessary knowledge during the repair process.

The barriers found in the literature review and those found in the field research were similar, such as perceived lack of skill, time, and effort required. Reducing these challenges through clear fault diagnosis tools and intuitive instructions can increase confidence and success rates.

Ownership also plays a role; consumers are less likely to repair appliances they don't own, especially when they risk liability for damages. This highlights the importance of tailoring repair solutions to those who are most likely to attempt self-repair. Addressing these factors through effective design interventions can make self-repair more accessible and appealing to consumers.

In addition to these specific insights, the field research activities were a great contributor to understanding the ATAG repair context, as seen in chapter 2.

Together with the insights from the literature, this research forms the basis for the design direction, formulated in the next chapter. The design requirements stemming from the field research are listed at the end of the next chapter on page 43.

5.
DESIGN DIRECTION

Intended user
Design goal
Interaction vision
Three intervention moments
Design requirements

The Design Direction chapter establishes the foundation for the design by outlining the key factors that will influence it. It begins by identifying the intended user, focusing on those most likely to engage in self-repair. Next, a design goal is defined, clarifying the objectives the solution aims to achieve. Then, the interaction vision is articulated, establishing the desired experience for users. Afterwards, the intervention moments from the literature are revisited and redefined. Finally, the design requirements translate research insights into concrete guidelines that the design must meet, ensuring feasibility and effectiveness. Together, these elements provide the foundation for moving into the ideation phase.

5.1 Intended user

The intended users identified in this research are: dishwasher owners whose warranty has expired or is no longer fully valid.

Dishwasher owners
Renters (of houses with included appliances) were found to be less likely to engage in self-repair, as the appliance maintenance is often included in the rent. However, this does not mean that the solution should exclude them completely; it should still be accessible and functional for all users.

Expired or no warranty
The Ride Along Day (page 33) shows that people rarely try to repair their dishwasher while it is still under warranty, as it is more cost-effective to rely on the services provided by ATAG. However, once the warranty has expired, consumers are more likely to consider self-repair and are therefore the focus of this solution.

5.2 Design goal

After the research phase design goal was set, in order to have a clear focus going into the ideation phase.

> To design an **intervention** that **increases the willingness to self-repair** for **owners of ATAG dishwashers** when they experience a **dishwasher malfunction at home**, **with guidance along the whole process and seamless integration of different elements.**

What
An intervention is a purposeful action, system, or strategy designed to address a specific problem or influence behaviour in a desired way. In the context of this project, an intervention refers to any solution, tool, or process that helps consumers overcome barriers to self-repair, making it easier, more accessible, and more successful.

Effect
The goal of this project is to increase willingness to repair, which should be reflected in the design goal.

Target
Dishwasher owners whose warranty has expired or is no longer fully valid, as explained earlier in this chapter.

When & where
Consumers have their dishwashers at home and repair is only needed when a malfunction occurs.

Direction
The direction gives more aim to the design goal and narrows down its focus. This direction stems from the earlier research findings and the design vision formulated in chapter 3.

5.3 Interaction vision

The way consumers interact with the proposed solution is important to helping them successfully repair their appliances. This section defines this project's interaction vision, outlining how the users should feel when they interact with the design solution. Through an analogy, interaction qualities are determined. Those interaction qualities lead to certain properties that can be translated into ways the ideas/concepts are generated, worked out, or detailed.

The interaction vision for this project is:
Making a smoothie (Figure 4)

Figure 14. Man making a smoothie (Brajdić, 2022)

The interaction qualities of this interaction vision and their accompanying properties can be found in table 4.

Table 4: Interaction qualities with accompanying properties

Interaction quality	Accompanying proprerties
Casual: Making a smoothie can be done on a whim, whenever you ingredients, and you need minimal equipment. Cleanup is simple and hassle-free.	Relaxed, informal, or non-intensive. **Infrequent or Spontaneous Use:** The product is not used continuously or for extended periods but rather on an as-needed basis. **Low Commitment:** doesn't require significant time, effort, or learning. **Everyday Context:** Often associated with everyday, routine situations rather than specialised or professional tasks. **Informal Setting:** Usage occurs without strict protocols or rigorous guidelines, making it easy to pick up.
Comfortable: Smoothies provide a delicious, nutritious, and satisfying snack. Their smooth, pleasant texture makes them nice and easy to drink, offering a sense of comfort and enjoyment.	Pleasant and easy to use for extended periods without causing (mental/physical) strain or frustration. **Physical comfort:** Ergonomic, fits well in the hand, or reduces physical effort. **Mental comfort:** Doesn't require excessive thinking, stress, or confusion. **Emotional comfort:** Feels reassuring and enjoyable to use.
Intuitive: To make a smoothie, a recipe is not required; you can throw some ingredients (fruit, juice, ice, (vegan) dairy, and vegetables) together and it will likely turn out well. If the flavour isn't quite right, it's easy to adjust by adding more ingredients until it tastes just the way you want.	Easy to understand and use without requiring prior instruction or a lot of cognitive effort. **Immediate Understanding:** Users can figure out how to use it naturally, without needing a manual or tutorial. **Familiarity:** The design aligns with common user expectations or behaviours. **Clear Feedback:** The product provides responses or cues that guide users through their actions. **Effortless Navigation:** Controls, features, and interactions feel logical and easy to grasp.

A fourth interaction quality was extracted from the literature:
Convenient: easy to access, use, or integrate into daily life with minimal effort.
Saves time & effort: Requires fewer steps or less hassle to use.
Accessible: Readily available when needed.
Fits seamlessly into routines: Doesn't disrupt normal usage patterns.

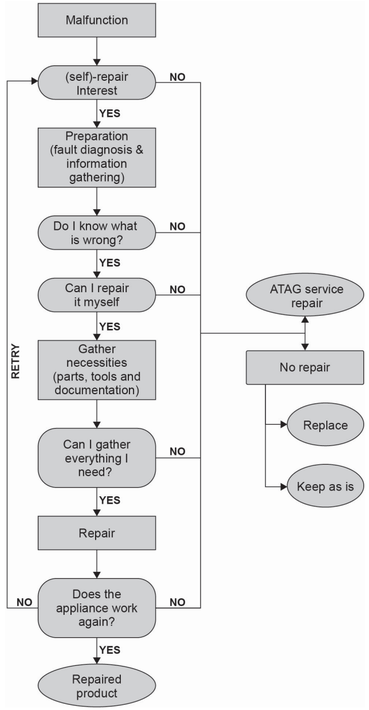


Figure 15. The repair process, adapted from Svensson-Hoglund et al. (2023)

5.4 Three intervention moments

After brainstorming, selecting the potential ideas, and sketching them out (chapter 6.1), three intervention moments were identified. Which are slightly different than the previously defined intervention, as shown in Figure 15.

In chapter 3.1.1 of this report, the research question "Which intervention points in the consumer self-repair process of a dishwasher can be identified?" was answered. This was concluded with the visual seen to the left. From this, three intervention moments were defined: preparation, gathering of necessities, and the actual repair.

While these moments are still deemed as valuable intervention moments, after further research, it was concluded that one part was still missing. When a customer has a broken dishwasher, the design should also ensure they do not immediately go online to buy a new machine. Therefore, a new intervention moment was added called: Replacement prevention. Furthermore, the gathering of necessities intervention moment was not deemed necessary. While the actions in this phase are important, they don't need an intervention moment for themselves, and therefore, this phase will be combined with the preparation. The names were also adapted to better encompass what the phases are mainly about, which led to the following three intervention points: 1. Replacement prevention; 2. Fault diagnosis help; 3. The right instructions (figure 16).

Each of these intervention moments has a unique functionality, which is shown in Table 5.

Table 5: intervention moment functions

1. Replacement prevention	2. Fault diagnosis help	3. The right instructions
· Helps consumers "bond" with their dishwasher · Increase repair mindset and stop people from considering replacement · Stimulates user to seek ATAG repair help in case of malfunction	· Help with fault diagnosis · Help with making a choice to self-repair · Helps the user continue · Streamlines the process for getting the right parts and equipment	· Helps with the act of replacing the broken component

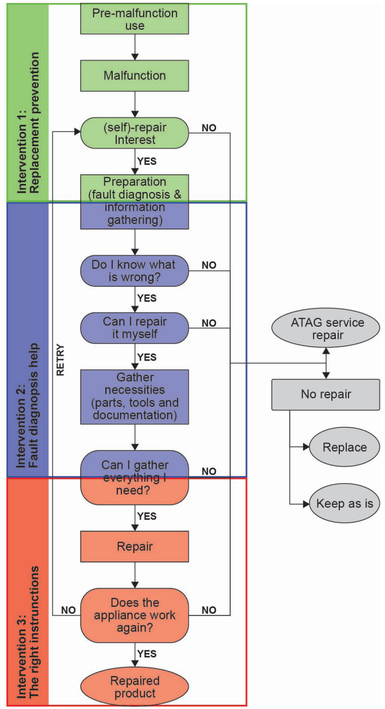


Figure 16. visual overview of the three repair intervention moments

5.5 Design requirements

Insights from the research phase were converted into one or multiple design requirements and categorised per theme. The full list can be found below.

Use conditions

1. Use of the design involves a minimal learning process
2. The interaction with the design follows the formulated interaction qualities
   a. Casual
   b. Comfortable
   c. Convenient
   d. Intuitive
3. The design integrates solutions for common practical challenges, such as obtaining the required tools, access to repair manuals and instructions, and ordering replacement parts.
4. The design uses clear language, visuals, and interactive elements

Financial

5. The design solutions are provided as a free service to ATAG consumers to keep the self-repair cost lower than the €100 service fee(excluding spare parts)
6. The design highlights the financial and practical benefits of self-repair to encourage dishwasher owners to self-repair.

Repair motivation

7. The design leverages the longevity of dishwashers to reduce the replacement mindset
8. The design communicates a repair summary, estimated cost, and repair time range after the fault diagnosis and before the actual repair.
9. The design makes consumers aware of the general repair efficacy (effectiveness & success of a repair), and after fault diagnosis, they are made aware of the specific repair efficacy
10. The design ensures users will feel that their skills are adequate before and during the repair.
11. The design is engaging

Repair preparations

12. The design makes users aware of potential safety and material risks for a specific repair
13. Before starting a repair, the design guides users through necessary preparations, including:
    a. Identifying and disconnecting relevant hoses and power cables.
    b. Listing required tools and ensuring they are present.
    c. Ensuring the workspace is cleared.
    d. Clearly outlining safety precautions (removing jewellery, wearing gloves).

Fault diagnosis

14. The design guides users in identifying the issue accurately, without the need for external assistance.

Repair instructions

15. The design provides clear, structured repair instructions.
16. The design presents the repair instructions in an interactive and visual way.
17. The designed fault diagnosis and instruction solution are interesting to use.

ATAG

18. The design fits within ATAG's digital repair landscape.

6. IDEATION

This chapter explains the idea generation process of this project, from the first ideas to the ones selected for further development. It starts with a review of the organised creative sessions. Next, the chapter briefly presents all the valuable ideas from these sessions. For each of the three intervention moments, one idea is selected for further development using the previously defined design requirements. These three ideas are

6.1 Creative sessions

6.1.1 Goal

Three creative sessions were organised to initiate idea generation and generate rich input with multiple participants (outside of the project) (figure 16).

6.1.2 Method

The first creative session was conducted with 2 ATAG employees. The subsequent two sessions involved industrial design master's students. These sessions had five and four participants, respectively. All sessions consisted of introductory exercises, a mix of diverging, converging, individual and group assignments. A brainstorming session was held for all creative sessions following the How-to Method described in the Delft Design Guide (Van Boeijen et al., 2020). A full planning of the sessions can be found in Appendix III, on page 101.

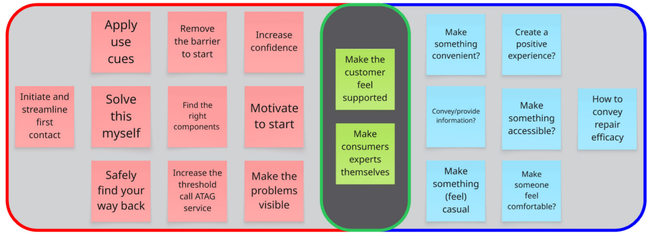


Figure 17. Overview of how-tos used during brainstorming

Figure 17 gives an overview of all the how-tos generated during the multiple sessions. The how-tos in the yellow section were formulated and used by the participants to generate ideas for self-repair during the creative sessions.

To support the generative sessions, additional How-to input from literature and field research was included, which is shown in the blue section. These were completed in a separate session. In which the researcher and a fellow industrial design student did a quick brainstorm to generate answers to all these how-tos.

The two how-tos in the green section were addressed in the creative sessions and extracted from the research. Therefore, they weren't used again in the last brainstorm.

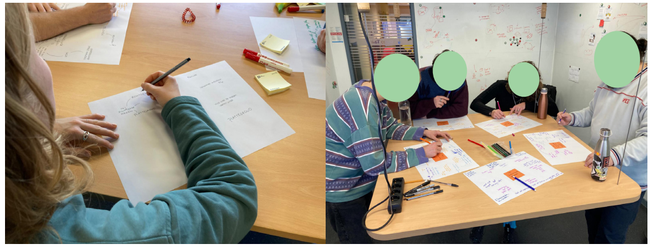


Figure 16 Pictures of creative sessions

6.1.3 Results

The results of these brainstorm sessions are multiple sheets containing intervention ideas, ways to reach certain interaction qualities and other ways to increase ATAG consumers' willingness to repair. All suggestions were carefully analysed and a pre-selection was made.

6.1.4 Idea selection

Only a select group of ideas was submitted to further elaboration.. An initial selection was made based on the ideas' relevance and viability. Some brainstorming results were only part of an idea, a suggestion, or an inspiration. These elements were also considered and combined with the ideas to form the following list of ideas from the brainstorming sessions.

Ideas with "DT" in front of them were originally part of one idea of creating a digital twin-inspired system with many functionalities. This idea was split up into separate functions, mainly because the different aspects are too dissimilar to be able to pick as one thing, and because these functions are diverse, and the complete idea would possess too many different elements to be able to detail within this project. All ideas from the initial selection, including a short description, are shown in Table 6.1 - 6.3.

Table 6.1, 6.2, 6.3: Initial selection of ideas categorised per intervention moment

Intervention 1 - Replacement prevention	
Idea	**Short description**
Board game	A simple 'ganzenbord' type of game that conveys the information through assignments done in the game.
Card game	A conversation starter game in which the players ask each other questions about repair and dishwashers.
Phone game	Educational phone game on the ATAG app that gets people in touch with how and why to repair.
Fact of the day app	An app that people can download that sends them a repair fact or question for them to think about.
(Online) newsletter	A newsletter that people can sign up for, which periodically tells them about repair benefits and repair updates at ATAG.
Adverts	Countrywide TV/billboard/online advertisements to convey the repair message.
Picture book	A children's picture book, parents can read with them to convey the repair message.
ATAG repair workshop	An ATAG organised repair workshop teaching people how they can repair ATAG products themselves.
Calendar	A calendar that people can hang in their homes and look at daily, reminding them about repairs.

Intervention 2 - Fault diagnosis help	
Idea	**Short description**
DT - Data logging wear tracking	Digital twin making predictions on which parts wear out quickest based on manually logged use data, logged by the user.
DT - Collective smart data (for fault diagnosis help, maintenance & cleaning advice)	All (smart) dishwashers of a certain model collect and compare data, using it to assist in fault diagnosis and predict which components might fail in the near future. Based on that, it can also recommend certain maintenance and cleaning actions.
DT- autonomous maintenance	Based on collective dishwasher data in comparison with your own, your dishwasher will execute maintenance and cleaning actions autonomously.
Flowchart fault diagnosis	An extensive flowchart to help the customer do the fault diagnosis independently.
DT - Error code fault diagnosis help	The digital twin systematically overviews the possible causes for a certain error code to assist in fault diagnosis.

Intervention 3 - The right instructions	
Idea	**Short description**
AR-repair instructions	Repair instructions projected via a smartphone screen onto the actual machine, using augmented reality on a smartphone.
Dishwasher scale model	A scale model of the dishwasher that consumers can assemble to better understand the machine and practice repairs.
Community support	A community-run support forum designed to help consumers with repair issues, incorporating an FAQ and "common problems" page as well.
DT –digital 3D model instructions	A digital 3D model to support the repair instructions, essentially creating an interactive instruction manual.
DT - AI digital assistant	Digital assistant within the digital twin that can "look with you over your shoulder" via your phone/tablet's camera and guide you through the self-repair process in a supportive way.

6.2 Idea selection

A Harris profile was used to decide which ideas to select. To streamline the process, similar ideas within an intervention were clustered together, and only the ideas that were deemed most worthwhile were evaluated. The selection was based on the defined functionality of the intervention moments. To further streamline the selection process, not every requirement was used on every intervention. A selection was made based on the requirements that were most relevant per intervention and would allow differentiation between the different ideas/clusters. Since some requirements target aspects of the repair process that are present in only 1 or 2 of the interventions. An overview of the reasons for picking the chosen criteria for the Harris profiles for all 3 interventions and the scoring criteria can be found in Appendix IV. After scoring, the ideas were given additional comments before picking or combining them to proceed with.

6.2.1 Intervention 1

The **board, card, and phone games** were grouped together because they all incorporate a game-based approach to engage users. Their core value lies in the interactive and playful element.
The **fact-of-the-day app** and **(online) newsletter** were clustered due to their similar method of delivering small, digestible pieces of information over time. Both aim to inform and gradually engage users through consistent, low-effort content.
The **calendar** concept was kept as a standalone idea, as its structure and function differ significantly from the others. It offers a more passive, visual form of engagement that doesn't rely on frequent updates or active participation.

Adverts were omitted because they would also reach non-ATAG users, making them a less efficient use of resources. Their broad targeting reduces their value for a brand-specific intervention.
The **picture book** was removed as it only appeals to a narrow segment, parents of young children, thereby excluding a large portion of the intended audience. Additionally, its novelty wears off quickly, limiting long-term impact.
The **workshop** concept was excluded due to the high time and cost investment required to reach a relatively small number of people. It also doesn't align well with ATAG's brand identity or operational model.

6.2.1.1 Harris profiles

A Harris profile is a tool for visually comparing multiple ideas based on a set of predefined criteria, arrangedfrom most important to least important. (Van Boeijen et al., 2020). Each idea is scored across several key aspects, and the scores are plotted on a chart. This makes it easy to see the strengths and weaknesses of each concept at a glance.

This method was used to make the evaluation more structured. Allowing a more objective comparison aligned with the selection criteria. The Harris profiles for intervention one are shown in Figure 18.

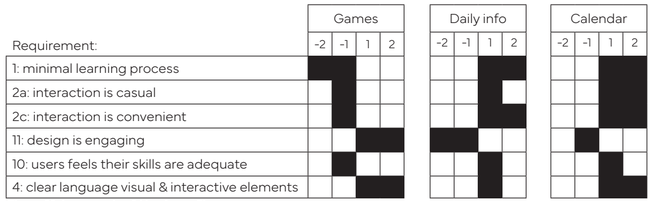


Figure 18. Intervention 1 Harris profiles

6.2.1.2 Additional comments

Games

- There is little repetition, as a game is played at most once a month.
- The game has to be fun to be played at all.
- Games (to change an interaction) usually work because one player gains some benefit from playing them and can initiate them. In this case, ATAG has a benefit, but they can't initiate the game. The players have a benefit, but they don't realise it until they play the game, so they're highly unlikely to initiate it.

Daily info

- The idea relies on people signing up/downloading themselves. If they don't, the idea automatically fails, and an app like this or a newsletter is not very enticing to subscribe to.
- The interaction with these interventions is very passive.
- Notifications likely to get lost among the other ones people receive.

Calendar

- Calendars need to have a certain appeal to them for consumers to start using them.
- After using the calendar for some time, users might not pay as much attention to it anymore.

6.2.1.3 Choice

Following the idea selection process, the calendar was chosen for further development. Based on the Harris profiles, it scored slightly higher than the other concepts regarding overall benefit. While all ideas received some critical feedback, the calendar's potential drawbacks were considered the least limiting, especially if offered for free to ATAG dishwasher or appliance users.

6.2.2 Intervention 2

Data logging for wear tracking, collective smart data for fault diagnosis and maintenance advice, and autonomous maintenance were omitted. These concepts depend heavily on the presence of smart dishwashers, which fall outside this project's scope. Furthermore, these ideas primarily serve as support tools for the fault diagnosis process rather than offering a complete solution in themselves. On their own, they are not actionable or valuable enough to stand as individual interventions. Still, they could be useful as integrated components in a larger smart system, which is not the focus of this project.

The flowchart and error code fault diagnosis help were evaluated individually (Figure 19, next page).

6.2.2.2 Additional comments

Flowchart fault diagnosis

True flowcharts look quite technical, which might scare away less technically inclined users.

DT - Error code fault diagnosis help

This idea was only envisioned to work with error codes, to link the problem to specific components that can be highlighted and displayed clearly.

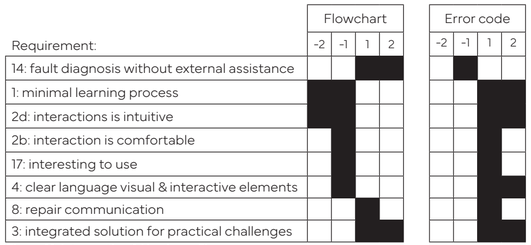


Figure 19. Intervention 2 Harris profiles

6.2.2.3 Choice

The decision was made to combine the flowchart and error code fault diagnosis concepts. Their Harris profiles showed almost opposing strengths and weaknesses, making them complementary. By merging the flowchart's robust, systematic approach with the error code tool's more intuitive and user-friendly experience, the resulting solution can offer a comfortable and accessible way to diagnose faults, even in cases where no error code is provided.

6.2.3 Intervention 3

Community support was excluded because similar platforms already exist that serve this purpose. For ATAG, developing and maintaining its own community would require significant resources for moderation and management, without offering a clear advantage. Furthermore, while community support may offer motivation or general advice, users would still need clear, structured instructions to effectively carry out the actual repair.

A scale model for practising repairs was also dismissed. While it could help users become familiar with the process, it would require them to spend additional time assembling and interacting with the model. Additionally, working with a miniaturised version may make the actual repair seem even more complex, as it introduces unrealistic constraints and may reduce users' confidence.

The other three ideas were evaluated individually (Figure 20).

6.2.3.2 Additional comments

AR instructions

While an AR overlay on a real machine in real time would help in creating clear visuals. It would be too impractical if users had to constantly point their phones at the machine, look at the phone, and perform actions on the machine to be able to use the instructions.

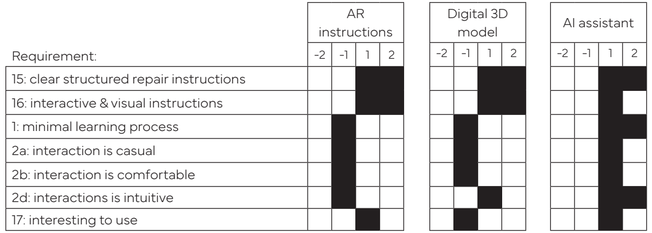


Figure 20. Intervention 3 Harris profiles

Digital 3D model

It would probably be a helpful solution, but it seems fairly conventional and as if it would not offer much added benefits over conventional written instructions supported with images.

AI assistant

The AI's "character" has to be considered carefully to appeal to a large number of users at once.

Only auditory descriptions can be difficult to understand for complex movements and locations.

6.2.3.3 Choice

The **AI assistant** was chosen as the concept to develop further, as it not only scored highest in the Harris profile and after consultation with an ATAG representative, it also stood out as the most inspiring direction for ATAG. In addition, the accompanying comments offered valuable suggestions for refining and improving the concept. Mainly incorporating the visual elements from the other 2 concepts.

A similar critique could be made of the AI assistant as of the AR instruction system: it requires the user to aim their phone at the machine to function properly constantly. However, a key difference makes this concern less relevant in the case of the AI assistant. For the AI assistant, visual feedback is optional and serves only as an additional crutch for clarification; the primary instructions are delivered through voice. As a result, users can maintain their focus on the repair itself and only glance at the screen when necessary. In contrast, the AR instruction system relies entirely on visual guidance displayed on the phone screen, requiring users to continuously look at and reposition their device to follow the instructions.

6.3 Chosen ideas

In the next section, the chosen ideas are elaborated on further, creating a more fully developed understanding of the ideas.

6.3.1 Intervention 1 – Replacement prevention

The calendar was inspired by trash day calendars; these calendars remind you when certain trash bins have to be put outside in order for the trash to be collected. For the calendar, multiple different types were considered, but eventually the birthday calendar was picked for the following reasons:

1. The same birthday calendars can be used yearly, ensuring ATAG doesn't have to make and send them yearly for consumers to be reminded of repair.
2. Birthday calendars are monthly, ensuring that certain information stays up for a month, and the user definitely can't miss it. It also ensures the same information is repeated multiple times in a month.
3. It also provides the user with the added functionality of a birthday calendar.

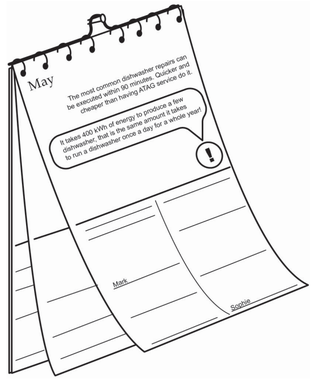


Figure 21. Sketch of calendar

The calendar's layout is a standard birthday calendar layout (figure 21). It has numbered lines to write the birthdays of friends and family, and some space where nice pictures would be shown in a regular birthday calendar, but that serves to present the

prompts that help accomplish the calendar's defined functions.

To keep the calendar interesting, many different types of prompts were created, which fall under the following categories:

Categories:	Example:
Dishwasher fun facts:	Your dishwasher heats water up to 60°C to dissolve grease.
Maintenance questions:	What is a common cause of a malfunctioning drain pump?
Conversation starters:	ATAG dishwashers are tested to last 12.500 cycles. This is an average of 12 cycles every week for 20 years! How many cycles do you think your dishwasher has done?
Dishwasher repair myths:	Myth: "A broken dishwasher is too expensive to fix." Fact: "Most common issues, like clogged filters and broken seals, cost less than $50 to repair."
Sustainability facts:	It takes 400 kWh of energy to produce a new dishwasher, that is the same amount it takes to run a dishwasher once a day for a whole year!
Self-repair motivation:	The most common dishwasher repairs can be executed within 90 minutes, which is quicker and cheaper than having ATAG service do it.
True or false questions:	You should always pre-rinse dishes before putting them in the dishwasher. False! Modern dishwashers and detergents are designed to handle food residues.

These prompts all serve the three functions defined for the calendar. On the right side of the page, an overview is given for each function the calendar needs to fulfil, with an example prompt that helps to achieve said function.

Function:	**Example prompt:**
Helping consumers "bond" with their dishwasher	*The filter in your dishwasher should be cleaned once a month to keep it running smoothly. Have you checked yours lately?*
Increasing the repair mindset and stopping people from considering replacement	*Your dishwasher isn't draining! What is the first thing you check?*
Stimulating to seek ATAG repair help	*Is your dishwasher broken, but you don't know what's wrong? ATAG has online troubleshooting tools available to help you diagnose the problem.*

The previous section pointed out that for the calendar to be effective, it would need to have a strong visual appeal. While this is a valid observation, the focus of this project is not on graphic design or branding, but on exploring how design interventions can support and encourage consumer self-repair. Developing and testing visual styles that resonate with a wide audience is a complex task that could easily warrant its own dedicated project. For this design process, the priority lies in shaping the intervention's structure, content, and interaction qualities. While visual design is certainly important for engagement, it will be treated as a secondary consideration here, with the assumption that further development could involve collaboration with branding or design specialists to refine the final aesthetic presentation.

6.3.2 Intervention 2 – Fault diagnosis help

Flowcharts are a proven way of troubleshooting something systematically. However, as mentioned in the previous section, the look of a flowchart can be intimidating. The visual aid and step-wise layout of the error code fault diagnosis is used to create a complete fault diagnosis solution that will also be pleasant to use. With a focus on the flow of the system rather than aesthetics.

The calendar tells people where to find this fault diagnosis help: in the ATAG app or on the website, where other service information about appliances can be found.

When starting the fault diagnosis, users first get an explanation of what the process entails and how the service works. After that, the users can either fill in the error code they received or troubleshoot based on a problem description in case they don't have an error code. For each error code/problem description, a specific fault diagnosis process is executed, ensuring an efficient troubleshooting process. Based on the answers users give on the different troubleshooting steps, a diagnosis is made. At the end of the process, users are told what part they have to order and replace, a time range for the repair, and what tools they need for it. They are also told how much money (service costs) they save by executing the repair themselves and are led to the spare part web shop and shown where they can find instructions for this specific repair.

Since ATAG already has flowcharts available for its mechanics, these can be converted into comprehensible steps for users to follow, as shown in Figure 22.

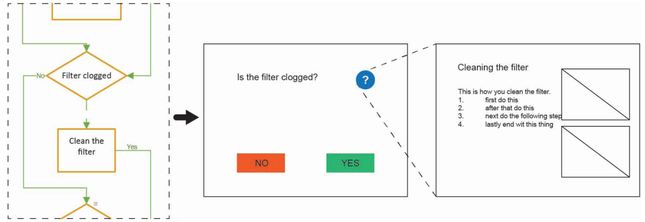


Figure 22. Conversion of ATAG flowchart steps into prototype steps

6.3.3 Intervention 3 – The right instructions

The third intervention introduces a novel approach to delivering repair instructions, drawing inspiration from two everyday scenarios. The first is the common habit among young adults of calling their parents for help with unfamiliar household issues. The second is how someone might learn to fix a flat bicycle tire through hands-on guidance from another person. These relatable examples show the value of real-time, conversational support when navigating unfamiliar tasks.

The idea consists of an AI voice assistant that can be integrated either in the browser or the ATAG app. The users' phone is set up in a way that the camera can "see" what the user is repairing. The AI assistant will then guide the user through the repair with voice commands. It can also show visuals (either highlighted pictures or schematic overviews of certain parts) of specific locations that might be difficult to describe. These can be offered to the user, if they need it, illustrated in Figure 23 (next page). As the assistant is also "looking over the shoulder" of the user, it will also correct them if the user accidentally does something wrong, and it will do this in a supportive and constructive way.

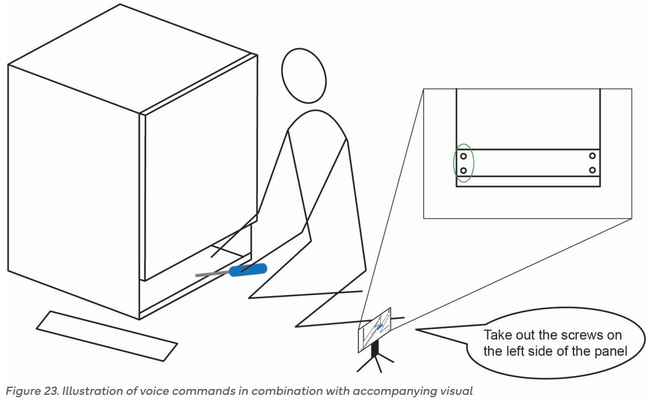


Figure 23. Illustration of voice commands in combination with accompanying visual

6.3.4 Storyboard

This chapter concludes with a storyboard which gives a clear overview of how the interventions are used and how they will help the repair process (figure 24, page: 55, 56 & 57).

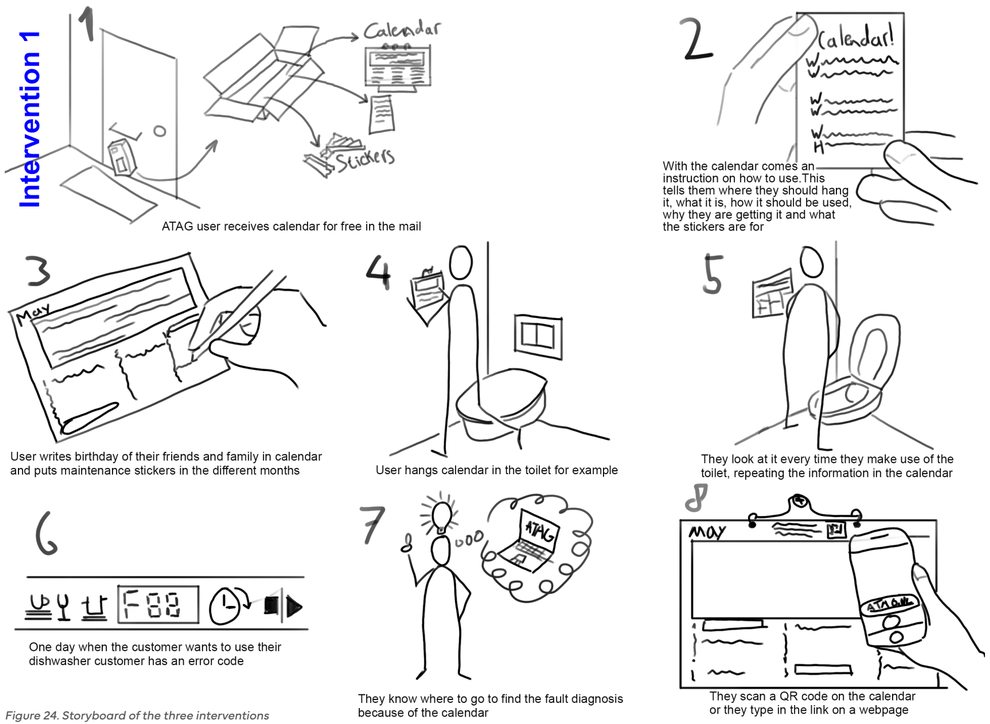
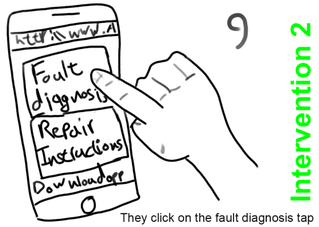


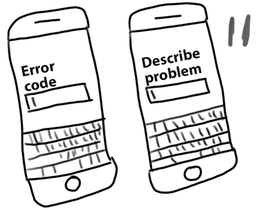
Figure 24. Storyboard of the three interventions



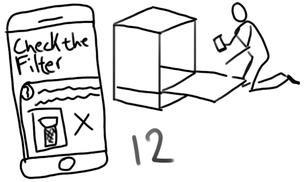
They click on the fault diagnosis tap

Intervention 2

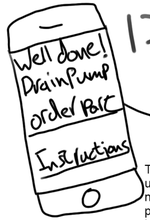
Pick “error code” or general problem



Fill in error code or describe the problem

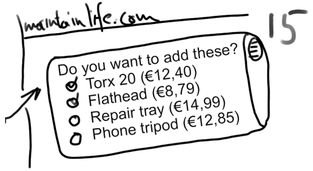


The fault diagnosis screen starts in which the user trouble shoots the different steps

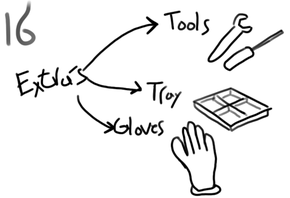


The end-screen lets the user know: Your drain pump needs to be replaced, buy spare parts here, get repair instructions here

User clicks “buy spare parts” and gets linked to maintainlife.com on the part they need

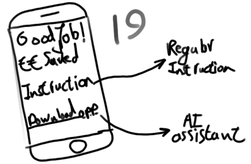


They put the part in the “basket” and get prompted with if they also want to get add-ons



Add-ons include the tools needed for the repair and other optional extras like gloves, trays, flashlights, etc.

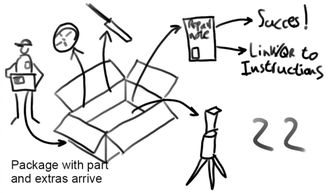
User takes what they need and places order



After order user gets prompted with a screen congratulating them on their self-repair journey, the ATAG service cost they are saving, links to the part specific repair instructions and link to download the ATAG app in which they can use the AI repair assistant

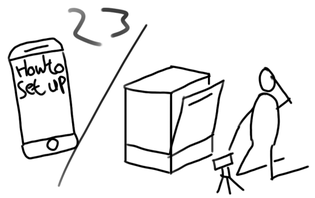
User downloads the ATAG app and then waits for the parts to arrive

Intervention 3

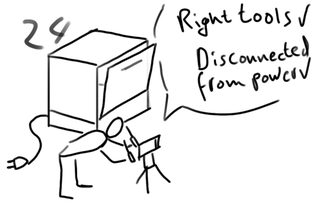


Package with part and extras arrive

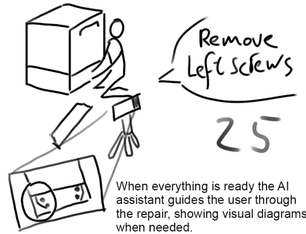
Also includes a flyer linkingto the app, instructions and it wishes the user good luck with their repair



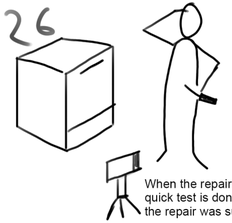
The user is instructed on how to set-up their phone



The AI assistant tells them how they should prepare and checks it the user has the right tools



When everything is ready the AI assistant guides the user through the repair, showing visual diagrams when needed.



When the repair is finished a quick test is done to ensure the repair was successful

The AI assistant congratulates the user with their successful repair and after cleaning up the user, feels proud, satisfied and glad that they don’t have to do the dishes by hand anymore

7.
PROTOTYPES & EVALUATION

This chapter outlines the process of the first iteration cycles. First, the primary objective is presented. Then, the basic structure of the tests is explained. The prototypes used in the tests are then described. The chapter concludes with the test results and the design changes resulting from these results are laid out in chapter 8.

7.1 Primary objective

The primary goal of these iteration cycles is to evaluate the proposed concepts' effectiveness in supporting consumer self-repair. This includes assessing what aspects of the idea are well-received, identifying potential drawbacks, and determining whether the concepts successfully reach their intended purpose.
Questions guiding this evaluation include:

- Do the ideas effectively achieve their desired functionality?
- Does the idea satisfy the chosen interaction qualities?
- What improvements can be made to support the intended goal of the idea better?

7.2 Approach

The approach is presented as it was in the second iteration cycle, after improvements from the first cycle were incorporated. The first iteration involved 2 people, after which some changes were made to the prototypes and test plan; subsequently, a second iteration was conducted with 2 additional people.

The general structure of the tests consists of evaluating each prototype in order, which can be roughly divided into four parts. In the first three parts, each idea is tested separately according to the three intervention moments defined earlier, with a general discussion after the third and last intervention. The last part is a general evaluation of all ideas combined. Each intervention is introduced with a short scenario explaining the situation in which the participant would use the prototype. After each scenario, the prototype is tested and evaluated before moving on to the next.

Although not necessarily part of the target group, the first prototype evaluations were conducted with fellow Industrial Design Engineering faculty students. Each test was conducted with one participant at a time, totalling four participants, and lasted approximately one hour. Next to the answers on the predetermined questions, , notes and pictures were taken. All materials were analysed after all tests were conducted.

7.2.1 Calendar

In the calendar test, the participant is given a scenario in which they have a broken dishwasher and don't know how to fix it. After the scenario, they are asked three Likert scale questions. They are then shown the prototype calendar and given time to look at it. Afterwards, they are asked the same three questions again, as well as several open-ended questions to evaluate the prototype.

7.2.2 Fault diagnosis

In the fault diagnosis prototype, the participant is given an error code. They then use the prototype to carry out troubleshooting steps on the dishwasher themselves to find out the fault's hypothetical cause.

7.2.3 AI assistant

For the AI assistant prototype, the participant is presented with a scenario where they must replace a specific dishwasher part. The scenario ends with the participant having received the spare part and having prepared the repair by gathering all the necessary tools and materials, leaving the participant to do the actual replacement of a "broken" part. The prototype is tested by the facilitator following a pre-written script to guide the participant through the repair. To support the vocal instructions, visuals were created showing the locations of certain parts if necessary. The session ended with a general discussion of all three prototypes together.

7.2.4 Test repair

A test repair was defined earlier in the report. These tests were conducted before this test repair was defined; therefore, this test focused on replacing the drain pump. The decision to focus on the drain pump is based on a few aspects: the use of several different connectors, relative inaccessibility, and the combination of water and electrical systems.

The complete test plan is overviewed in Appendix V.

7.3 Testing

Several prototypes representing the three interventions were created to conduct tests. The following section explains the prototypes, including the changes made after the first iteration cycle.

7.3.1 Calendar

A simple calendar was created in Word and printed on A4 paper. The model is a simple birthday calendar for 3 months with lines for names at the bottom and space for prompts at the top. Each month contained six prompts from different prompt categories. There are slight changes in prompt categories between months. Every month contained a few prompt categories with an answer that needed to be revealed by removing a sticker (Figure 25). The calendar includes a QR code directly linking the user to the fault diagnosis help or spare part web shop. Besides the calendar, the user is provided with a few stickers they can stick in the calendar and use to plan maintenance tasks for themselves, like cleaning the filter.

Although appearance is very important for birthday calendars, the decision was made to focus on the content and prompts first to see if these could achieve the calendar functions. Rather than creating a desirable calendar, the aim was to test whether the prompts would actually help in achieving the previously defined functionality of this intervention moment (machine bonding, increasing repair mindset & stimulating seeking ATAG repair help).

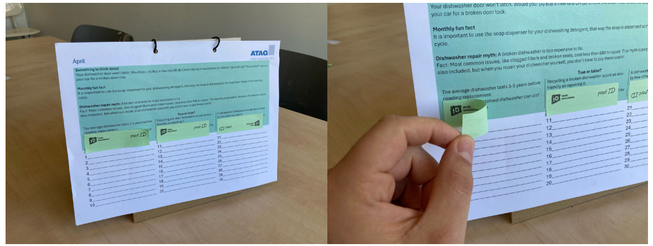


Figure 25. Calendar prototype

7.3.2 Fault diagnosis

To make the fault diagnosis prototype, an existing flowchart that ATAG mechanics might use was used as a guideline. Part of this flowchart was converted into a clickable prototype using PowerPoint, viewed on either a laptop or smartphone. The prototype represents the user flow users would have to go through, explains how to do the troubleshooting in a stepwise manner and how to perform the cleaning/maintenance steps in between (Figure 26).

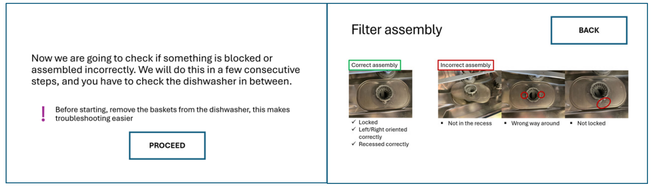


Fig 26. Example pages from the fault diagnosis prototype

The basic layout of each page consists of a question for the user to check a certain component. The page includes a button to the help page, explaining how to do the step, and buttons to continue to the next step (figure 27).

The last 2 pages (after the problem has been diagnosed) congratulate the user and tell them how to continue with their self-repair journey. Figure 28 provides a schematic overview of the whole layout. Since the test scenario included an error code, the fault diagnosis prototype was also focussed on the fault diagnosis.

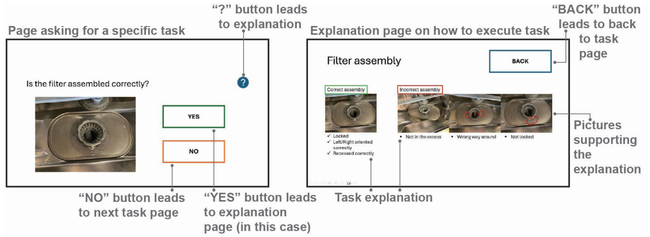


Fig 27. General layout of fault diagnosis pages

7.3.3 AI assistant

As prototyping a real AI voice assistant was deemed too time-consuming and not within the skill limit of the project, the choice was made to "act out" the AI assistant. To do this, a script was written to describe the determined repair (drain pump replacement). The script was written to fulfil the chosen personality traits for the AI assistant, which are: eager, supportive, casual and comfortable. To visually accompany the spoken instructions, several visuals were made to help the participants during key moments in the repair, which can be found in Figure 29.

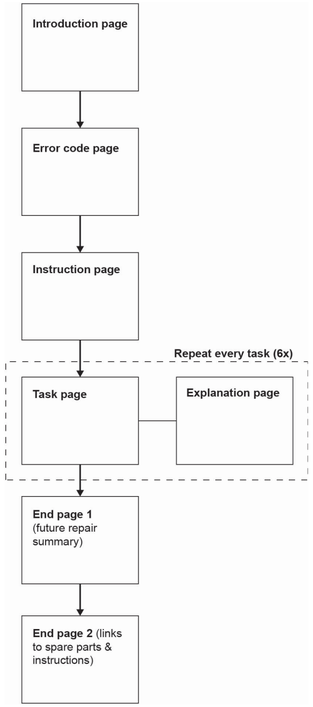


Fig 28. Fault diagnosis prototype layout

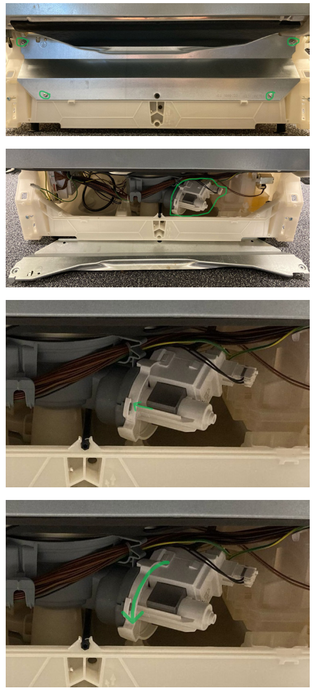


Figure 29. Visuals supporting the repair

7.4 Results

7.4.1 Calendar

Likert scales

Since only four participants filled in the Likert scales, the results lack strong validity. However, they still provide a useful indication of whether participants' attitudes toward self-repair, ATAG's repair service, and replacement changed after interacting with the prototype.

Most participants' likelihood of self-repair increased by one or two points, except one. Several participants mentioned that their decision would still largely depend on how much time they had available.

When asked about contacting ATAG for repair services, participants' scores remained relatively unchanged. However, most noted they would attempt the repair themselves first and only contact ATAG if unsuccessful.

Responses to the question about immediately replacing the dishwasher showed that the participants scored very low (around -3) before seeing the calendar. All participants said they would first attempt to repair the appliance, whether by themselves, through ATAG, or with the help of someone they know. This was probably because the questioned participants were all industrial design engineering students who have relatively high technical ability, while having relatively little money to spend.

Questions

Responses to the open-ended questions varied among the four participants, though there were occasional points of agreement.

Most participants said they would not hang the calendar because they felt it wasn't visually appealing. For two participants, the calendar could not replace the one they already use. However, for three out of four, the fact that it was a calendar positively influenced the likelihood of its use.

Only one participant said they did not find the information on the calendar interesting at all. The others agreed that the content positively influenced their attitude toward self-repair. Reasons included the potential cost savings, the calendar giving reasons why the repair might not be as complex as previously thought, and the encouragement provided by ATAG itself.

Two of the four participants said they already had a birthday calendar at home and could recall much content from it. This indicates that a birthday calendar can be useful for making users aware of information or helping them remember things.

Participants gave various suggestions for improving the calendar, including what to add, remove, or modify. One point of unanimous agreement was the need for

more visual elements, both to enhance the calendar's appearance and to support its content. For example, one participant commented, "I don't know what a Torx20 screwdriver is; I would've loved to see a picture of that."

At the end of the session, participants were asked what they could still remember from the calendar. All recalled that ATAG offers repair support and remembered the general style and topics of the prompts. Most were also able to recall specific prompts in detail and the types of prompts present on the calendar; most participants also remembered a few of the prompts exactly.

7.4.2 Fault diagnosis

All participants agreed that they liked using this method for fault diagnosis, particularly the step-by-step guidance and how it was tailored to their personal situation. This isn't the case if you look for repair help or YouTube videos online, which is what they indicated that they normally would've done.

They also stated that, now that they know what is wrong with the machine and are presented with clear next steps, they would be more likely to attempt the repair themselves.

Participants found the overall look and feel of the interface familiar and easy to understand. Some comments were made about the specific order of steps and interface details, but these were minor and can be refined through further testing. Two participants also mentioned that the experience reminded them of another app they had used, suggesting a level of familiarity.

The visual support was well received by all participants. They said they would like to see more of it, noting that images with overlaid illustrations were helpful. Additionally, they preferred that visuals accompany step-by-step instructions rather than simply showing "right vs. wrong" examples, which was the case with the filter positioning.

Fig 30. Participant unscrewing front cover

7.4.3 AI assistant

All participants agreed that they liked this method of receiving support during a repair. Aspects they appreciated included the direct feedback, reassurance that they were performing steps correctly, the ability to ask questions, and not having to figure out the next steps themselves. One participant said, "It feels like someone is watching with me who knows what's happening." All participants said they would like to use this type of guidance again in future repair situations.

Only one participant used visual aids during the test, but they noted that the images helped clarify the situation immediately.

Participants also responded positively to the voice assistant's personality, describing it as clear and to the point. When asked what traits they would like the assistant to have, several were mentioned: friendly, kind, reassuring, patient, and calm. Two participants specifically noted that the assistant should never say how "easy" something is, as this can be discouraging if the user is struggling to complete the task.

One point that had not been considered beforehand was the potential resistance to allowing AI access to a phone's camera. This concern was raised by one participant and suggests a need to address privacy expectations in future development.

7.5 Conclusion

7.5.1 Calendar

The main goal of these tests was to determine whether the calendar prompts would increase users' willingness to carry out self-repairs. The results suggest that the prompts were effective in encouraging this behaviour. However, participants noted that the calendar would need a visually appealing design for them to actually use and engage with it regularly.

Although the interaction qualities were not assessed directly, participants' responses indicate that they experienced the calendar as both casual and convenient.

Several participants also expressed a desire for more interactive elements beyond simply reading the content. They felt the calendar should help create a stronger connection between the user and the dishwasher. At the same time, participants admitted that they did not feel connected to either their own dishwasher or the one used in the test. This is understandable in the test setting, as the appliance was a standalone built-in model with no added context or personal relevance, and participants had never used it before.

7.5.2 Fault diagnosis

It can be concluded that this prototype achieved its intended goal, and participants responded positively to this method of fault diagnosis. The step-by-step approach was particularly appreciated. Although the version tested was a simplified version of a full fault diagnosis process, the core interactions were well-received.

If ATAG were to develop this prototype further, more detailed testing would be needed, especially regarding the timing and placement of information, the design and layout of buttons, and the visual support provided for each action.

While interaction qualities were not assessed directly, participants' responses to other questions suggest that the interaction felt both comfortable and intuitive.

7.5.3 AI assistant

The participants enjoyed being guided by an AI assistant during the repair process and even mentioned that this approach made the experience more enjoyable.

Although interaction qualities were not assessed directly, responses to other questions indicate that the interaction with this fault diagnosis method was perceived as casual, convenient, and intuitive.

7.5.4 Overall

It can be concluded that participants responded positively to the repair process, with some even stating that they enjoyed it overall. They also noted that using the prototypes to guide the repair required less effort than they had initially expected. Completing the repair in this way left participants feeling satisfied and empowered. However, that does not mean the prototypes worked perfectly yet. These tests also found many improvements, which proved valuable for further development.

Based on these conclusions, changes were made to the 3 prototypes. The 3 full concepts are overviewed in the next chapter.

7.6 Idea changes

All idea changes made, based on the insights from the test and suggestions of the participants, are incorporated in the conceptualisation of the ideas in the next chapter.

8.
THE CONCEPTS

Calendar
Fault diagnosis
AI assistant
How the AI system works

This chapter develops the three interventions into distinct concepts, each incorporating insights from the previous tests. Due to time constraints, the final phase of this research project will focus on the AI assistant for repair instructions since the calender concept and the fault diagnosis concepts were deemed less promising.

8.1 Calendar

8.1.1 The concept

Some general changes were made in the calendar's conceptualisation. The concept is made to stand on a surface or hang on a wall hook to give people options on how they want to use the calendar. This allows users who think it is too much effort to hang it an option to use it as well, figure 31.

In Figure 32, the calendar is shown with all the elements and annotated changes.

The layout and visual elements of the design are not yet final. The current layout provided space for images and prompts, ensuring the content remained clear and accessible. An orange visual accent was added to suggest a possible design direction and to bring some colour to the prototype, which otherwise appeared quite plain and uninviting. However, this is merely a preliminary idea and does not represent the visual design the calendar should have if it were to go into production.

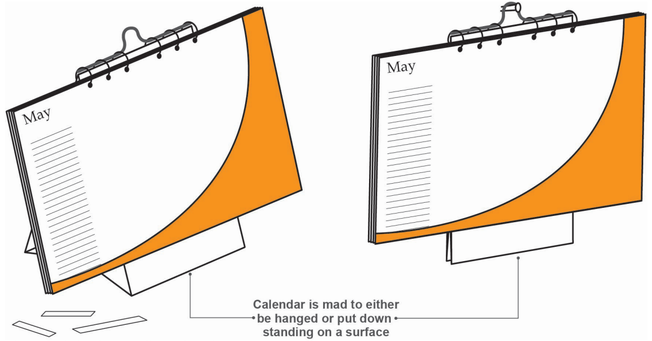


Figure 31. Calendar standing or hanging

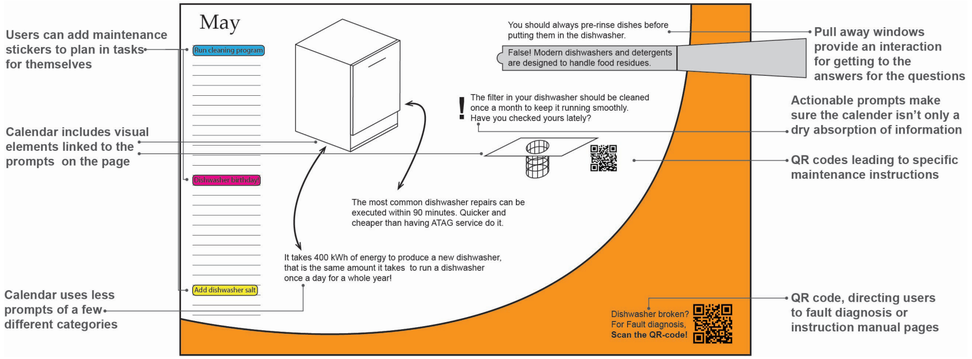


Figure 32. explanation of calendar elements

The updated calendar concept introduces a few new features to better engage users and encourage maintenance behaviour. Users can add their own maintenance stickers to plan tasks, making the calendar a more personal and practical tool. Each page includes visual elements that relate to the prompts, enhancing clarity and appeal. Rather than overwhelming the user with every possible message, each page features stickers to plan tasks, making the calendar a more personal and practical tool. Each page includes visual elements that relate to the prompts, enhancing clarity and appeal. Rather than overwhelming the user with every possible message, each page features a curated selection of prompts from two or three different categories, keeping the content focused and manageable.

To add a playful element, a pull-away window is included, offering a small interaction for revealing the answers to question prompts, making the experience a little more engaging. Within the prompts themselves, some are designed to be more actionable, ensuring the calendar goes beyond passive information-sharing and instead encourages actions. To support this, QR codes have been added that link directly to the specific maintenance tasks mentioned in the prompts, allowing users to access these instructions easily. Each page also includes a QR code that leads to either ATAG's fault diagnosis tool or to relevant repair manuals, providing immediate access to help when needed.

8.1.2 Choice

The calendar idea was not chosen for further concept evaluation due to several uncertainties surrounding its use. It remains unclear whether users would actually use the calendar or engage with it regularly enough for it to be effective.

However, the informational prompts used in the calendar, have potential in encouraging self-repair, could still be valuable. A more promising direction would be to integrate these prompts into the existing ATAG app (Figure 33), which is already used for smart appliances. As the number of smart dishwashers is expected to grow in the coming years, embedding the prompts in a digital environment offers a more future-proof and scalable solution. While the physical calendar may not be viable in its current form, the underlying content can still play an important role when adapted to a more sustainable, app-based platform.

8.1.3 Recommendations

Based on the development and testing process, several recommendations can be made to further enhance the concept. First, due to time constraints, this project did not fully address the final visual design. The look and feel should be developed to connect with the users of ATAG kitchen appliances. It may also be worth considering a different design style for each of the five brands, given that they each have slightly different product lineups and target audiences.. A more polished and appealing design would help ensure that users are not only drawn to the calendar initially but also motivated to continue using it over time.

Additionally, the prompts used in the prototype could be made more actionable. While many were informative or reflective, incorporating prompts that encourage specific actions, such as designated cleaning tasks or checks, could enhance user engagement and usefulness.

There is also an opportunity to include more thought-provoking or challenging questions, especially those that encourage users to reflect more deeply on their habits, motivations, or knowledge about repair. Incorporating the calendar function in the ATAG app might work even better than a physical calendar, however.

Translating the calendar concept into a digital app presents several opportunities

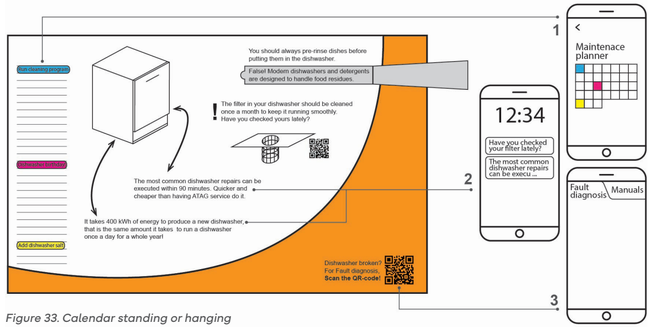


Figure 33. Calendar standing or hanging

for future expansion and adaptability (Figure 33). A clear advantage is the ability to send push notifications, reminding users of important repair prompts and upcoming maintenance tasks (2). Users can choose to schedule maintenance themselves or allow the app to handle it automatically (1). After a task is completed, the app can schedule the next one based on the typical time interval for that type of maintenance, streamlining the entire process.

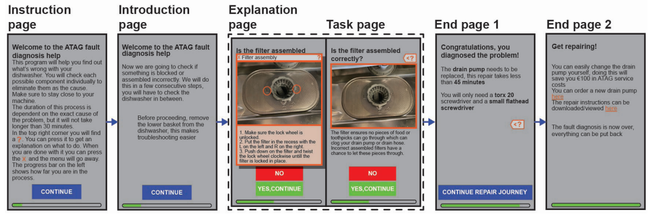


Figure 34. Schematic overview of fault diagnosis layout

To enhance the bonding potential between users and their dishwasher, the app could incorporate various prompts, either as push notifications or within the app itself. For instance, tracking the dishwasher's "birthday" or celebrating milestones, such as the 1,000th wash cycle or dishwasher run time, can make the product feel more personal and valued. Moreover, an app-based version would enable users to manage multiple ATAG appliances more efficiently. Instead of requiring a separate calendar for each device or learning about appliances they do not own, users could easily add their own appliances to the app and receive relevant updates and content tailored to those specific models.

Lastly, the app could seamlessly integrate other tools, such as fault diagnosis and repair instructions, removing the need to scan QR codes or search manually (3). This would create a central, user-friendly platform for both inspiration and action surrounding appliance maintenance and repair

8.2 Fault diagnosis

8.2.1 The concept

In Figure 34, the general layout of the fault diagnosis model is shown. Before these screens are opened, the user has filled in their error code or problem description in the app. Based on that, the app starts the right fault diagnosis model.

The introduction page (figure 35) welcomes the user and sets expectations for the experience. It explains that the user should remain near the dishwasher throughout the process and provides an estimated duration, including a maximum time, so users know what to expect. It also introduces the help feature, which opens an overlay whenever additional clarification is needed, when the question mark icon is tapped.

The instruction page gives a brief overview of how the diagnosis process will work. It explains the progress bar and tells the user to prepare their workspace before continuing, such as by removing dishes and baskets from the machine.

The explanation and task pages work together as a pair. The task page tells the user what action they need to perform as part of the diagnosis, while the explanation page provides an explanation on how to perform that action. The explanation appears as an overlay on top of the task page, ensuring the pages feel as one. Based on user testing, the decision was made to have the explanation overlay open by default, as some users initially overlooked it. These two pages have been directly converted from an existing ATAG fault diagnosis flow chart, just as the previous prototype.

End page 1 congratulates the user on completing the fault diagnosis, clearly states what the diagnosed fault is, and which part needs to be replaced. Then, it tells the user something about the function of the part and where it is located approximately. Lastly, it provides an estimated time range for the repair and lists the tools required to perform it.

End page 2 encourages the user to attempt the repair themselves. It highlights the potential cost savings compared to using an ATAG service mechanic and offers direct links to spare part ordering pages and detailed repair instructions.

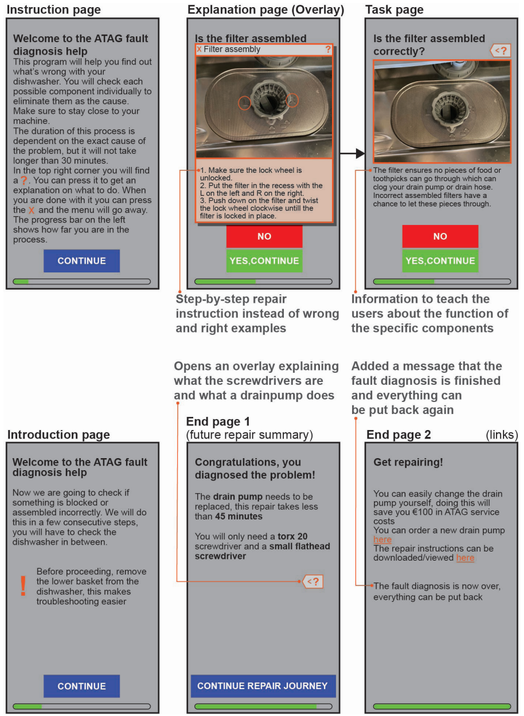


Figure 35. detailed view of every type of page in the fault diagnosis

Furthermore, careful attention should be given to the clarity, tone, and sequence of the instructions. They should be written in simple, step-by-step language, avoiding technical jargon wherever possible. Written instructions need to be written out completely, assuming the user does not know any of the steps. Visuals should clearly correspond to each step, highlight key components or actions, and be positioned alongside the related text to support quick understanding. Using consistent symbols, arrows, and close-up views can further improve user comprehension.

The fault diagnosis can be adapted from existing ATAG flowcharts. Figure 36 shows the minimal explanation a mechanic receives and how that flowchart step is converted into a fault diagnosis step suitable for consumers.

8.2.2 Choice

This concept was not chosen for further development for two main reasons. The first is that the previous test indicates that people like this method to help them with fault diagnosis. The existing flowcharts need to be converted into this concept, and a new version needs to be made for repairs that do not yet have a matching flowchart currently. After that, larger-scale tests can be done to validate whether this idea can be a successful method for more problem diagnoses. This is the main step that needs to be executed to develop this concept

Figure 36. detailed view of every type of page in the fault diagnosis

further. The second reason concerns the fine-tuning of the user interface. A large part of the development process would involve defining the precise layout, interaction flow, and design elements, followed by extensive testing to determine whether ATAG users find the interface intuitive and appealing. Together, these challenges make the concept less suitable for further development within the scope and timeline of this project.

8.3 AI assistant

8.3.1 The concept

Like AI in popular culture, this AI is also given a name: IRIS, which stands for Interactive Repair Instruction System. This not only sounds better and makes it easier to refer to, but it also helps users interact more as a human rather than an unembodied computer program. This concept starts when the user receives their package containing the spare part, an information flyer linking to the instructions and other extras, like tools and safety materials, they ordered with it (figure 37).

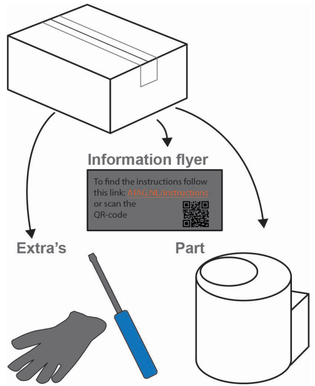


Figure 37. Content of spare part order, including optional tools and safety equipment

Before the actual AI assistant instructions start, the user has to choose their dishwasher model in the ATAG app. This can be done by choosing one from the list or scanning the QR code on the model sticker. This app contains instructions on where to find the sticker containing the model information and QR code (figure 38). In the case of smart machines the app would already be connected.

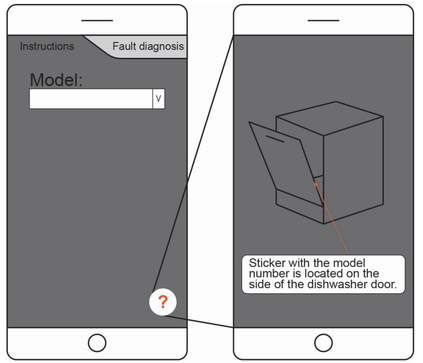


Figure 38. Pre AI assistant start screen in ATAG app

Since the app is mainly based on voice commands, the layout is very simple and consists of only two screens (Figure 39).

A few changes and additions were made to the app to improve clarity and usability. A green exclamation mark now appears whenever a visual aid is available, signalling that visual clarification is ready to help the user better understand the situation. To help users who are hesitant to give an AI access to their camera, the app also shows the user what the camera/AI is seeing in real time. For example, when the camera detects a hand, the screen will display the hand with a visible

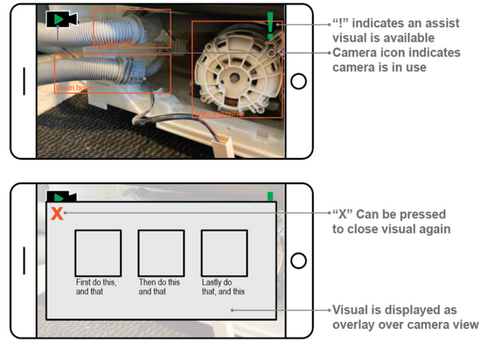


Figure 39. App screens of the AI assistant

square around it. This gives users an insight into what the AI sees and how it processes this information.

Several improvements have been made to the AI assistant's scripting (Appendix VI) to create a clearer, more supportive repair experience for the user. To begin with, the assistant now includes a short summary at the start of the interaction, outlining what the user can expect during the repair process. This helps set expectations and reduces uncertainty.

Throughout the repair, the assistant regularly communicates the next steps, maintaining a sense of structure and helping the user stay oriented. In addition to giving direct instructions, the assistant now provides brief explanations to clarify why certain actions are necessary, supporting user understanding and confidence.

At the beginning of the repair, the assistant highlights which steps are more sensitive, such as those involving fragile components or higher risk. It either briefly names these steps or notes that they will come with additional explanation, ensuring the user feels better prepared.

These changes are incorporated in the script of the validation test plan in Appendix VI.

8.3.2 Choice

The AI assistant concept was chosen because it presents the most forward-looking and innovative approach. With further refinement, it has the potential to inspire ATAG by demonstrating a new and engaging way to deliver repair instructions. Rather than relying on traditional manuals or step-by-step guides, this concept reimagines how users interact with repair support, making the process feel more dynamic, personalised, and accessible. In the next section, the technical challenges and possible solutions to those challenges will be illustrated.

8.4 How the AI system works

Several challenges have to be addressed with an AI system like this one. It is important to explore these technical challenges to understand the feasibility of such a system. To approach this methodically, the functionality of the AI assistant was divided into six main aspects.

1. Natural language understanding and processing
2. Dialogue management
3. Voice & visuals integration
4. AI model training and integration
5. Camera integration
6. Device and model identification

Below, the primary challenges for each function are explained, along with solutions to address them.

8.4.1 Natural language understanding & processing

A key requirement for the assistant is understanding spoken input from users and responding with relevant, easy-to-follow guidance, because the assistant must accurately interpret user questions, comments, and feedback during a repair task.

8.4.1.1 Challenges

- Speech recognition errors (in noisy environments, like a kitchen can be).
- Understanding different phrasings for the same request.
- Ambiguity in user input, like vague questions or missing context.

8.4.1.2 Possible solutions

To solve the first issue, a speech recognition model capable of handling background noise and variations in phrasing might be integrated. A model such as OpenAI's Whisper is suitable for this purpose (Gladia - What Is OpenAI Whisper?, n.d.). To ensure that user queries are interpreted correctly, a natural language understanding (NLU) model would need to be adapted to work with domain-specific language related to repair and dishwashers (or other kitchen appliances) (Gillis, 2024).

To deal with ambiguous or unclear input, the assistant should include a fallback mechanism, such as asking clarifying questions or repeating previous steps, to ensure users stay on track during the repair.

8.4.2 Dialogue management

Unlike a regular written repair guide, an AI assistant must manage a conversation that adapts to the user's pace, level of understanding, and any deviations from the expected sequence. The assistant needs to guide the user logically step-by-step and respond appropriately to questions or confusion (Bhatnagar, 2024).

8.4.2.1 Challenges

- Ensuring users don't skip important (safety) steps like unplugging the appliance.
- Managing non-linear conversations (users jumping back to earlier steps or asking off-topic questions).
- Maintaining context throughout the session.]

8.4.2.2 Possible solutions

To solve these issues, the assistant needs to be built in a way that helps it "remember" which steps in the repair process the user still has to do and what has already happened. This could be done using a checklist or a flowchart behind the scenes, that the assistant follows step-by-step (Adamopoulou & Moussiades, 2020). Each time the user confirms they've done something, or the camera sees that the user has done something, the assistant moves on to the next item on the list. At the same time, it should allow some flexibility. For example, if the user says, "Wait, how do I unplug the hose again?" The assistant should be able to go back and repeat that specific part without losing track of the overall progress.

To make this work, the system could use existing tools designed for building conversations with AI (like Rasa(Conversational AI With Language Models | Rasa Documentation, 2025), which uses a customised version of a large language model. It can also handle unexpected questions or small talk while keeping the user focused on the repair.

8.4.3 Voice & visuals integration

The AI assistant is also envisioned to show visuals to help the user understand the situation in cases where pure spoken instructions aren't enough.

8.4.3.1 Challenges

- Synchronising the right visual aids with the spoken instructions.
- Users may not have both hands free during repair.

8.4.3.2 Possible solutions

The visuals must be synchronised with the spoken steps and tailored to the user's specific dishwasher model. For accessibility, all visuals should be available to access via both voice and touch input, allowing users to interact in the way that suits them best at a certain moment. Since humans will make the visual aids beforehand, there will be no need to incorporate a visual AI model to generate new pictures during the repair.

8.4.4 AI Model training and integration

AI needs to be trained to understand and respond to specific types of information accurately. An AI model learns by analysing large amounts of data. For a repair assistant, this means training the AI with real repair manuals, technician instructions, and customer questions so it can recognise common problems, understand user requests, and provide the correct guidance. Without this training, the AI would not know enough about dishwashers or how to help someone fix one effectively (Chen, 2023).

8.4.4.1 Challenges

- Lack of publicly available repair conversation datasets.
- Domain-specific vocabulary (technical terms, tool & part names).
- Maintaining the accuracy and reliability of repair steps.

8.4.4.2 Possible solutions

The core of the AI assistant would be powered by a language model (like GPT) trained specifically on repair-related content. Because public data in this domain is limited, ATAG could create a tailored dataset using its own repair manuals, technician procedures, and service logs. These datasets should be machine-specific, as even minor differences between dishwasher models can influence the repair process.

To deliver accurate, up-to-date, and context-aware guidance, the assistant could use a retrieval-augmented generation (RAG) model in combination with a large language model (LLM) such as GPT. A RAG model is used to search a connected database and retrieve information such as internal documentation or repair instructions based on the user's input. An LLM is an AI

system trained on vast amounts of text data to understand and generate human-like language, enabling it to perform tasks such as answering questions, summarising information, and assisting with writing (OpenAI, 2023). This allows the model to use this specific information without needing to be trained on it. The language model then uses that retrieved content to generate a clear and helpful response (Martineau, 2024).

This approach enables the assistant to go beyond general knowledge and provide targeted support tailored to the user's specific appliance and situation, increasing the reliability and relevance of the guidance.

8.4.5 Camera integration

Integrating the phone's camera allows the assistant not only to guide the user with voice and visuals but also to "watch" what the user is doing and give immediate feedback, like having an expert "watching over your shoulder" supervising your actions. For this to work effectively, the system must be able to recognise both user actions and dishwasher components, and link this visual information to the current stage of the repair process. This provides the following challenges to overcome.

8.4.5.1 Challenges

- Recognising the user's hands, actions and the dishwasher's parts in real time
- Training a vision model to work in the dishwasher repair context
- Detecting errors in the user's actions and generating the right feedback
- Integrating the vision part with the rest of the system

8.4.5.2 Possible solutions

To enable this, the assistant would need to integrate a combination of hand tracking and object recognition models. For example, a model like OpenPose can detect and follow hand positions and gestures (Writer, 2024). This model is already being used (in fitness apps, for example) and provides real-time pose detection. An object detection model such as YOLOv8 (Solawetz, 2025) can be trained to recognise dishwasher parts. Together, these models would allow the system to interpret what the user is interacting with and how.

However, readily available models do not understand dishwasher-specific parts or actions. Therefore, ATAG would need to develop a custom dataset containing images and videos of common repair scenarios, parts, and actions to train OpenPose and YOLOv8 with. These should include various lighting conditions, part orientations, and common hand movements, all labelled with annotations (e.g., "filter," "drain pump," "incorrect tool use," etc.). This would allow the object recognition model to be fine-tuned specifically for ATAG's different appliances and repair situations.

Once a hand or part is recognised, the assistant would need to compare the user's actions to the expected step. If the assistant sees, for example, that the user is turning the wrong screw, it could intervene with a prompt such as: "It looks like you're turning the wrong screw, turn the screw below it instead." These prompts would be generated by connecting the visual recognition outputs to the assistant's dialogue system, which would adjust its guidance based on what the user is doing.

8.4.6 Device and model identification

The AI assistant must know what dishwasher model the user owns to give accurate guidance, which might be difficult since many dishwashers are built-in and have few apparent identifiable features on the outside.

8.4.6.1 Challenges

- Users might not know their specific model number.
- Repair steps might differ between seemingly similar models.

8.4.6.2 Possible solutions

Every dishwasher already has a sticker with information needed to identify it on the side of the door. The platform that hosts the AI assistant can simply add instructions for the user to check this sticker and input the model number. In the case of smart machines, the app is already connected to the specific machine, and this step is unnecessary. If the user, for any possible reason, is unable to provide this information, the assistant could use guided questions to help narrow down the model type based on visible features or controls.

8.4.7 System overview

In the Figure 40 the system is represented in a schematic overview including the different AI models that are needed.

To enable the AI assistant's functionality, the user's voice and video feed are transmitted from their phone through the app to a cloud-based system. The cloud handles the computationally intensive tasks that cannot be processed locally on the phone. For this setup to function effectively, a stable internet connection is required throughout the repair process.

The incoming video feed is analysed using two parallel models: one for recognising hand gestures and the other for identifying objects. These models are linked to the system's internal repair logic, which allows it to verify whether the user is handling the correct part and performing the correct actions. If a mismatch is detected, the assistant can intervene with corrective feedback. This feedback is generated by combining insights from the visual models compared to the internal repair logic, with contextual understanding provided by a large language model (LLM).

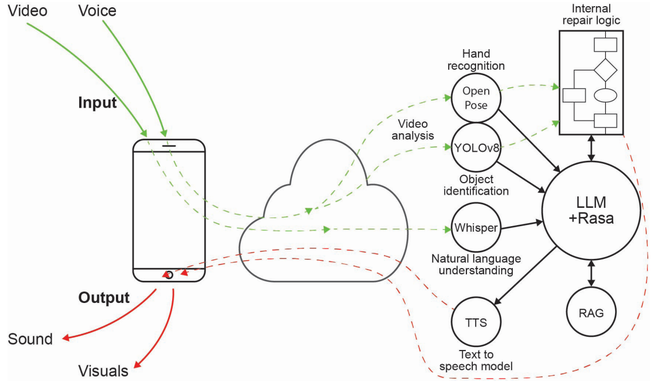


Figure 40. schematic overview of the working of the AI assistant

The user's spoken input is processed by a natural language understanding (NLU) model, which converts speech into text. This text is then passed to the LLM, which interprets the user's intent and generates an appropriate response. To improve the flow of interaction and allow for backtracking or rephrasing, the system is supported by a dialogue management tool such as Rasa. This helps maintain a natural, conversational feel, enabling the assistant to respond flexibly to different user inputs.

In the background, the LLM is further enhanced by a retrieval-augmented generation (RAG) system and ATAG's internal repair logic. This combination enables the assistant to generate accurate, context-specific instructions and answers based on up-to-date repair documentation.

Lastly, a text-to-speech (TTS) model converts the LLM's response into spoken language, which is played through the user's phone speakers. Simultaneously, the internal repair logic synchronises the appropriate visuals on the screen.

8.4.8 Privacy

When visual diagnosis or real-time object recognition is involved, user privacy must be addressed.

8.4.8.1 Challenges

- Concerns about allowing the assistant access to the camera or microphone.
- Variability in lighting and positioning for image recognition.
- Device constraints (battery, processing power).

8.4.8.2 Possible solutions

Because the AI-assistant includes camera functionality, privacy concerns need to be addressed. Users might be hesitant to allow camera access. To mitigate this, all camera use should be transparent and communicated. Image recognition can be done transparently, with the AI indicating what it thinks it is seeing on the screen and letting the user know what information is being processed. Furthermore, an option can be added not to use the camera. This would reduce the effectiveness of the concept, but would allow people who are hesitant about allowing AI to access their camera to also use these instructions.

8.4.9 Conclusion

To be able to vocally guide users through a repair, IRIS needs to rely on multiple systems working together seamlessly. Fortunately, many of these technologies already exist and can be adapted for this purpose.

Successful implementation depends on ATAG's ability to develop a high-quality, appliance-specific dataset. This would require collecting and structuring repair manuals, technician notes, and error codes across different dishwasher models. Integration of all system components must also be managed to ensure smooth, real-time interaction. Although the development process would involve a significant initial investment in time and resources, the core technologies and models are already being used and readily accessible.

Implementing the AI assistant concept would require significant effort, likely necessitating the establishment of a dedicated department within ATAG, or outsourcing it to a company specialised in developing these types of AI solutions. However, once such a system is developed and operational, its value could extend well beyond ATAG's own product line. By adapting the assistant to interface with the product databases of other appliance manufacturers, ATAG could potentially license the system to third parties. Although patenting may be difficult for the general concept of voice-guided repair, ATAG could protect specific technical implementations or datasets. This would allow other companies to offer similar repair support to their own customers, expanding the concept's reach and impact, and providing ATAG with a revenue stream to recoup the losses made with the development.

Whether it is worthwhile for ATAG to pursue this opportunity depends on several factors. On one hand, developing such a system could position ATAG as a forerunner in the industry and innovator in digital service support. This could enhance the company's brand image and attract new customers who value innovative, accessible repair options. On the other hand, the scope of the task should not be underestimated. Building and maintaining an AI-powered assistant at this scale would be a considerable undertaking, especially given that ATAG does not currently possess in-house expertise in AI development.

There are already AI-powered repair systems on the market, such as GE's SmartHQ Service Assistant (SmartHQ Service | AI Assistant, n.d.) and Service Alliance Group's AI Appliance Triage Tool(Revolutionize Appliance Repair With The AI Appliance Triage Tool, z.d.). However, these tools are primarily aimed at professionals and are designed to streamline fault diagnosis and surface relevant technical information. They do not offer real-time, conversational voice-guided repair support for consumers. This reveals a gap in the market, one that this IRIS concept could potentially fill. While this opportunity is promising, there are still many technical hurdles to overcome and a long development process to complete. ATAG needs to carefully consider if they are willing to invest in creating a service that helps their customer base self-repair from which they don't directly benefit financially. While the functionality and interaction of IRIS can be tested and proven, there is also no guarantee that IRIS will be widely adopted by consumer self-repairers.

9. VALIDATION

After selecting the IRIS concept and developing it further, a final validation test was conducted. This chapter outlines the main objective and approach of that evaluation. It explains the prototype used during testing and presents the findings from the user tests. A conclusion is formulated, and the chapter closes by identifying potential design improvements based on insights gained from the test.

9.1 Primary objective

This user test aimed to evaluate the overall usability and user experience of the IRIS prototype. The evaluation focused on how well the prototype met the previously defined design requirements and targeted interaction qualities|: casual, comfortable, convenient, and intuitive. Specific attention was given to how users interacted with the assistant, how clear and helpful the visual aids were during the repair process, and how the perceived personality of the assistant influenced user confidence and satisfaction.

9.2 Methodology

The test phase included one pilot followed by four complete user tests. Participants were aged 29, 34, 58, and 62, with an even gender split (two male, two female). Previous experience with repair in general was varied, and none of them had any prior experience with dishwasher repair. Each session lasted approximately one hour and included an introduction, a short pre-repair interview, the repair task (soap dispenser replacement), and a post-repair interview. As only one moderator was present, the entire repair process was video recorded to support more thorough analysis afterwards.

The full test plan, including the repair script, can be found in Appendix VI.

9.3 Prototype

Given the scope and timeframe of this project, it was not feasible to build a functioning AI assistant. Instead, a representative prototype was created. In this setup, the participant used a phone that was in a video call with the researcher. The phone's camera was active and pointed at the repair process, while the researcher's camera was turned off. The researcher shared their screen to control which visual aids appeared on the participant's phone, allowing them to simulate the assistant's voice and visuals. The researcher was stationed in a separate room to ensure all communication occurred through the phone and that the repair was only visible through the participant's camera (Figure 41).

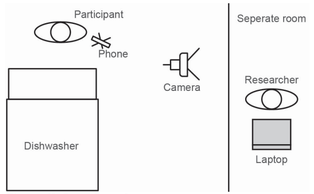


Figure 41. Overview of test set-up

In Figure 42, three particpants can be seen repairing the dishwasher during the prototype test.

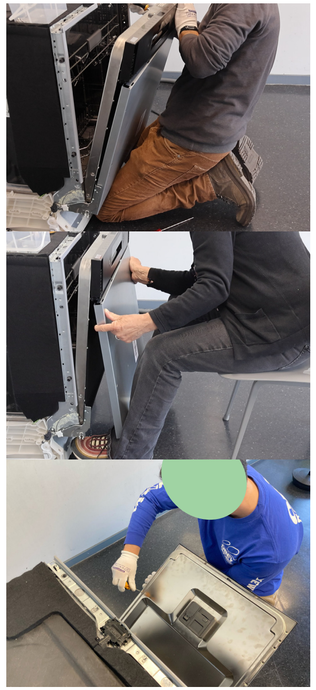


Figure 42. Particpants executing a repair

9.4 Results

9.4.1 Likert scales

During the test, the participants were asked to self-evaluate their repair ability. After the repair, they were also asked to fill in a Likert scale on the presence of the interaction qualities in the design. The leftmost side represents the lowest presence of repair ability/ the interaction quality, and the right side the highest presence, on a scale of 1-7 (Figure 43).

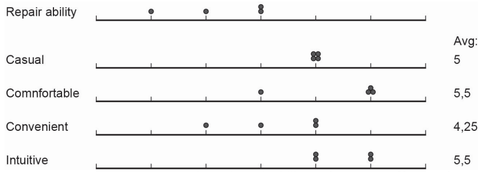


Figure 43. Likert scores of self-evaluated repair ability and presence of interaction qualities

9.4.2 Observations

It was observed that IRIS's camera-based support was used only occasionally during the repair process. In most cases, participants were able to resolve issues through conversation and the provided visuals without needing to bring the camera in for close-up checks. Only in very specific situations did participants move the camera closer for IRIS to verify their work.

Typically, participants positioned the camera to capture a general overview of the repair area, allowing the whole scene to be visible but making it difficult for IRIS to assess fine details accurately. However, the alternative, having participants continuously move and aim the camera while simultaneously performing the repair, was also perceived as undesirable. Participants seemed to struggle with managing both the camera and the repair task simultaneously.

In some instances, participants showed visible frustration when, after settling into a working position, IRIS prompted them to look at a visual aid that appeared on their screen. This occasional disruption suggests that the timing and delivery of visual prompts should be handled with greater sensitivity to the user's physical engagement in the repair.

9.4.3 Interview

The results of the post-test interview will be discussed per category.

General

Participants generally had a positive experience using IRIS. They particularly appreciated receiving direct feedback, progressing at their own pace (unlike pre-recorded instruction videos), and receiving reassurance when unsure about their actions. The combination of voice guidance with supportive visuals was valued, and several participants mentioned that the system made them feel less alone in tackling the repair. This was not an effect that was strived for, but it is a positive additional effect. It is unclear whether the users would also feel this way when executing the repair with a real AI instead of a person portraying the AI. Warnings provided by IRIS were also appreciated, as they allowed users to anticipate and prepare for upcoming steps.

On the negative side, some participants needed time to adjust to the system, particularly the switch between listening to audio instructions and consulting the visual aids. The most commonly mentioned challenge was the practical difficulty of balancing the phone: keeping it correctly positioned to capture the repair while simultaneously viewing the on-screen visuals.
All participants agreed that the step-by-step instructions were easy to follow. However, the participant with the lowest repair confidence suggested they would prefer even simpler, shorter steps.

All participants described the repair process as engaging, particularly when they could ask a direct question and receive targeted help through the camera view.

Finally, all participants reported feeling that their skills were adequate both during and after the repair. One participant noted that their confidence was higher once they had successfully completed the task than during the repair.

Visuals
Participants found the visuals' content clear and helpful, although several mentioned that in some cases, the images and accompanying text or numbers were too small to read easily.

The participant with the lowest repair ability appreciated the visuals but preferred seeing an action demonstrated via video before attempting it themselves. While the combination of voice instructions and static visuals was adequate, they felt that short demonstration videos could further enhance understanding.

Voice
Participants agreed that IRIS's tone of voice struck the right balance between formal and informal. Some technical terms, such as "snap joint" or "solenoid valve," were unfamiliar to a few users; however, most participants were able to deduce the meaning from context.

All participants felt that IRIS helped them feel more confident in their ability to repair. One participant even noted that they appreciated the absence of social pressure they might have felt if a friend or family member had assisted them.

The participant who scored their repair ability the lowest mentioned that, at times, instructions felt too long or packed with too much information at once, making them harder to follow.

IRIS' Character
Although participants did not explicitly describe IRIS as "constructive" or "supportive," they frequently used terms such as friendly, helpful, and neutral. They appreciated IRIS's straightforward personality and thought an AI assistant like this shouldn't have that much character at all, with one participant stating, "I don't need to become friends with it; I only need it to help me with my repair."

All participants indicated that they would use IRIS again for future repairs.

9.5 Conclusion

9.5.1 Interaction qualities

With only four participants, no statistically significant conclusions can be drawn from the results. Additionally, no direct comparison was made with participants performing a similar repair using conventional instructions, meaning no benchmark is available. However, based on the interaction quality scores presented in the previous section, the following lessons may be learned:

Casual
All participants gave the same rating for casualness. Although the score was not particularly high, it leaned toward the casual end of the spectrum. From participants' comments, it became clear that the repair task itself, repairing an expensive appliance, is inherently not perceived as a casual activity, which may explain why casualness was not rated higher.

Comfortable
Three participants rated comfort highly (6 out of 7), while one participant scored 4. This lower score aligns with their feedback: they found some instruction steps too long and containing too much information at once. While the current design provides sufficient comfort for participants with moderate repair experience, improvements are needed to better support users with less experience by further simplifying and breaking down instructions.

Convenient
Convenience received the lowest average score among the four qualities. Participants highlighted that constantly switching between repairing and looking at the phone was inconvenient, especially when the phone was set up at a distance. When the phone was kept closer, users had to reposition it frequently to show IRIS what they were doing, or they had to hold it while also using tools, both of which were described as frustrating and impractical.

Intuitive
Intuitiveness received a relatively high average score of 5.5. Participants noted that IRIS felt less intuitive in certain moments, mainly due to some visuals being unclear or difficult to read, and the need to switch attention between the phone screen and the physical repair task. Improving the coordination between voice instructions, visual aids, and camera interactions is likely to further enhance the intuitiveness of the system.

9.5.2 Design requirements

The following design requirements were evaluated during the test.

1. Use of the design involves a minimal learning process
2. The design uses clear language, visuals, and interactive elements
3. The design ensures users will feel that their skills are adequate before and during the repair.
4. The design is engaging
5. The design provides clear, structured repair instructions.
6. The design presents the repair instructions in an interactive and visual way.
7. The designed fault diagnosis and instruction solution are interesting to use.

Requirements 3 and 4 were addressed directly in the post-test interviews. All participants responded positively, indicating that these requirements were fully met.

Although requirements 1, 6, and 7 were not explicitly asked about, analysis of participants' answers across all interview questions shows that the prototype successfully met these requirements.

Requirements 2 and 5 were not addressed directly either. However, based on participant feedback and observations, it can be concluded that these requirements were only partially met. Some participants found certain visuals difficult to interpret due to their size or clarity, and a few had trouble following repair steps that were too lengthy or complex.

Several design improvements are proposed for the qualities that received lower scores and for the requirements that were not fully achieved. These are detailed in the next section.

9.6 IRIS design changes

The user tests revealed several areas where the repair experience could be improved. A major advantage of using an AI system powered by a large language model (LLM) is its inherent flexibility: it can adapt to different user profiles, repair skill levels, and personal preferences. This flexibility extends to the assistant's personality and how instructions are delivered, for example, through simpler language, more detailed steps, or varied visual support.

If implemented by ATAG, this adaptability should be fully leveraged to create an optimal repair experience for a diverse range of users. One way to achieve this would be to offer users a settings screen in the app before starting a repair. Here, they could adjust sliders to set their preferences regarding instruction detail, visual aids, and the desired level of support.

The system should also allow for dynamic adjustment during the repair itself. Users could tell IRIS to provide more or less detailed explanations depending on their confidence or experience as the repair progresses.

Other specific improvement points include:
Expanded Visual Support: Some users would benefit from short videos showing others performing the repair tasks, in addition to static images.

Technical Language: Use technical terms only when necessary, and provide brief, optional explanations to avoid overwhelming less experienced users.
Increasing Casualness: To create a more casual, reassuring atmosphere, IRIS's tone of voice could be made slightly more informal and friendly, potentially incorporating light humour. However, this adjustment should be carefully considered, as it may not fully align with ATAG's more serious and formal brand identity.

Incorporating these adaptations would make IRIS more user-friendly and allow a broader range of users to experience repair instructions that they prefer to help them successfully perform their self-repairs.

9.7 Test limitations

While the user test provided valuable insights into the strengths and weaknesses of the IRIS prototype, several limitations should be acknowledged when interpreting the results. These limitations, listed below, highlight factors that may have influenced user experiences, the representativeness of the findings, and the reliability of conclusions drawn from the test.

Researcher as AI Assistant
During the test, the researcher assumed the role of IRIS. Although the script was closely followed, occasional improvisation was necessary to respond naturally to participants' actions or questions. As a result, elements of the researcher's personal communication style may have influenced participants' perception of IRIS's personality, rather than reflecting the intended neutral character of the AI assistant.

Potential for Bias
Despite emphasising that the evaluation was about the product, participants may have given more positive or wishful responses because they were aware that the researcher was also the designer of the prototype.

Small Sample Size
Only four participants completed the full user test. This limits the generalisability of the findings and prevents any meaningful statistical analysis.

Prototype Fidelity
The test simulated IRIS via a video call rather than a real autonomous system. This may have influenced the naturalness of the interaction and the technical performance users experienced.

Controlled Environment
The tests were conducted in a controlled setting. Real-life conditions at home (such as bad lighting, limited space, or unstable internet connection) were not fully replicated, which could affect user experience in practice.

Limited Task Complexity
Only one type of repair task (soap dispenser replacement) was tested. Other repairs might present different challenges, meaning that findings may not fully represent the system's performance across a broader range of repairs.

10. CONCLUSION

This final chapter closes off the report. It begins with an overarching conclusion summarising the project's key outcomes. Following this, a set of recommendations is provided for ATAG, should they choose to further develop the proposed concepts. The chapter then outlines the project's limitations and concludes with a personal reflection on the process and experience of conducting this project.

10.1 Overall conclusion

This project set out to develop a practical solution that increases consumers' willingness to repair and encourages more frequent self-repairs by applying theoretical insights on repair influences to a real-world context. This objective led to the development of three distinct design concepts, each addressing a different aspect of the self-repair journey. One concept focuses on preventing a replacement-oriented mindset and fostering a stronger connection between users and their appliances. Another offers autonomous support for fault diagnosis, while the third introduces a novel, voice-guided approach to repair instructions. The conclusion begins by discussing the concept centred on repair guidance.

10.1.1 IRIS

One of the most important findings from the user tests is that direct feedback significantly enhances the repair experience. Unlike traditional instructions, where users must independently interpret written or video-based guidance, IRIS allows users to ask questions, receive immediate clarification, and continue confidently. This immediate reassurance reduces insecurity during the repair process and lowers the psychological threshold to attempt self-repair.

Participants particularly valued this ability to get tailored support in real time, which helped them overcome moments of doubt that could otherwise have led to frustration or abandonment of the repair. In this way, the direct feedback capability distinguishes IRIS from existing methods and plays a central role in making self-repair more accessible and less intimidating for users.

10.1.2 The calendar

While improving repair instructions is valuable, the decision to repair ultimately rests with the individual, and that choice is shaped by mindset as much as by information. The calendar concept developed in this project aimed to support that mindset shift, but it may not be the most effective solution in its initial form. Encouraging a broader cultural shift toward repair requires time, coordinated efforts across multiple sectors, and consistent reinforcement. Given this project's limited scope and duration, it is difficult to assess how much change is taking place. However, positive developments in legislation suggest that the landscape is gradually moving in the right direction.

Rather than developing the calendar as originally envisioned, ATAG would benefit more from adopting the key insights behind it. Encouraging users to engage more actively with their appliances, through timely prompts, maintenance tips, and reminders, can still be a valuable strategy. Integrating these elements into ATAG's existing app would offer a more scalable and user-friendly way to support this engagement, while leaving room to evolve and expand the concept further over time.

10.1.3 Fault diagnosis help

The fault diagnosis help developed in this project demonstrates that with the right support, consumers are capable of identifying issues with their dishwashers independently. By guiding users step by step and tailoring the experience to their specific situation, the concept significantly lowers the threshold to begin a repair. Although the current prototype focused on a simplified version of the process, the results suggest that this type of tool could make self-repair more approachable, less intimidating, and ultimately more successful. With further refinement and integration into ATAG's digital ecosystem, this intervention can potentially empower users while reducing reliance on service visits.

10.2 Recommendations

While the IRIS prototype showed promise, it remains unclear whether AI-supported repair guidance offers a significant advantage over more conventional formats such as videos or visual step-by-step manuals. Before committing to full-scale development, ATAG should first evaluate whether users truly prefer and actively use an interactive AI assistant like IRIS, compared to the repair instruction formats they already offer.

In this project, the decision was made to keep the functionalities of each concept aligned with the three intervention moments defined in Chapter 5. This allowed for focused exploration and testing of distinct solutions tailored to specific parts of the repair journey. However, there is a strong case for expanding IRIS beyond just step-by-step repair guidance. With relatively minor adjustments, mainly expanding its training data and retrieval sources, the system could also support users during fault diagnosis. Given that the platform infrastructure would already exist, extending its functionality in this way would require modest additional effort and could offer considerable added value.

The final user test also revealed that the camera-based support in IRIS was only helpful in a few specific scenarios. Should ATAG move forward with this concept, they may choose to omit the camera feature in early implementation stages and introduce it later or omit it altogether. A fully functional and valuable version of IRIS could be developed as a conversational-only tool, where users describe the issues they encounter. This would significantly reduce technical complexity and development costs while providing a compelling and effective repair experience.

10.2.1 Future proofing

Several opportunities for future integration and expansion can be considered to ensure the long-term relevance of the concepts. One way to do this is to incorporate fault diagnosis directly into the ATAG app. In the case of smart appliances, sensor data from critical components could be used to predict likely faults. This would make the diagnosis process both shorter and more accurate, reducing the burden on the user and increasing repair success rates.

In parallel, the development of the AI assistant could follow an incremental approach. Rather than aiming for a fully conversational system from the outset, ATAG could begin by offering high-quality repair instructions enriched with instructive visuals and clear success checks. This would help users build confidence and better understand the repair process. Over time, these simpler interventions could be gradually extended into a more interactive AI-based solution.

10.3 Project limitations

While this project delivered valuable insights and promising design directions, several limitations should be acknowledged.

Due to time constraints, there was no opportunity to analyse or test the existing repair instructions and materials currently being developed for ATAG consumers. These resources may already be clear and effective, but the focus of this project was to explore novel and future-oriented self-repair solutions. As a result, a direct comparison with current offerings was not part of the scope.

The topic of liability, particularly around who is responsible if a user damages their appliance during a self-repair, was also excluded from this project. This is a complex legal issue involving consumer rights and manufacturer responsibility. While highly relevant, it falls outside the design-focused scope of this research and would require dedicated legal analysis.

The duration of the project limited the depth and scale of user testing. While initial validation was carried out, the sample size was small and may not fully represent the diversity of ATAG's user base in terms of age, technical skill, or ownership situations. Furthermore, due to time constraints, the three interventions were developed and tested independently. Although this allowed for focused exploration of each concept,

it did not allow for integrated testing or analysis of how the interventions might work in combination.

Another limitation is the artificial nature of the testing environment. Since participants were not repairing their own dishwasher and faced no real consequences if something went wrong, their motivation and perceived risk may not have fully reflected real-life behaviour. Similarly, the tests did not take place in an actual home kitchen, meaning users were not confronted with real-world obstacles such as tight cabinetry, limited lighting, or difficulty accessing water or power connections. While the proposed concepts are designed to be adaptable across various home settings, practical integration, such as locating the power cord or water drain, was not explicitly addressed. These aspects should be incorporated in future development to ensure the concepts function effectively in diverse home environments.

Finally, the project did not address what happens when users fail to diagnose a fault or complete a repair, which is a likely scenario in real-life use. In future development, a fallback system should be included to support users in these moments, such as escalation to customer service or live chat support. Building in this safety net can help maintain user confidence and ensure a positive repair experience, even when things don't go as planned.

Lastly, the technical feasibility of the AI assistant (IRIS) was explored primarily at a conceptual level. While the proposed architecture is grounded in existing technologies, actual implementation would require significant investment, infrastructure, and cross-disciplinary expertise.

11.
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12.
APPENDIX

I. Full overview of repair influences
II. List of practical repair tips
III. Planning creative session
IV. Harris profile criteria
V. Test plan first test
VI. Test plan final evaluation
VII. Approved project brief

12.1 Appendix I. Full overview of repair influences

RED: the factor cannot be influenced within the context this project
BLUE: the factor is influential within ATAG's context, but it is outside of the scope for this project
GREEN: the factor is relevant within the context of this project

Table 7: Categorised repair influences and influence on repair

Dimension	Repair influencce	How it influences self-repair
Economic consideration	Cost of repair	High cost of repair-service would increase the chance on self-repair
	Cost of spare parts	High cost of spare parts decreases chance on repair
	Initial item cost (of broken product)	High initial item cost would increase the chance on repair
	Replacement cost	High replacement cost would increase the chance on (self-)repair
	Declining prices for new purchase	High replacement cost would increase the chance on (self-)repair
	Mental Book Value	Low mental book value would increase the chance on repair
	Trade value and utility value	High trade value increases chance on repair, High utility value increases chance on repair
	Linkage between Financial Incentive and Attitude	When attitude is stimulated with financial incentives it would increase chance on repair
User aspects	Sociodemographic aspect	A demographic that is more likely to self-repair could be chosen, but the sociodemographic factors cannot be changed within this project.
	Required skills	Higher skill increases the chance on self-repair
	Required knowledge	Higher knowledge increases the chance on self-repair
	Attitudes and motivation	Higher motivation increases the chance on self-repair
	Environmental concern	Higher environmental concern increases the chance on repair

Dimension	Repair influencce	How it influences self-repair
User aspects	Frugality	High frugality increases the chance on repair
	Innovativeness	More innovative users are more likely to self-repair
	Perceived behavioural Control	High perceived behavioural control increases the chance of self-repair when self-repair is the intended behaviour
	Trust in repair efficiency	Hight trust results in increased chance on self-repair
	Lack of confidence	More confidence increases chance on self-repair
	Perceived negative feelings (of throwing products away)	More negative feelings increase chance on repair
	Perceived interest	Higher perceived interest increases chance on repair
	Perceived pleasure	Higher perceived pleasure increases chance on repair
	Required time & effort	More time & effort decreases chance on repair
	Lack of information	Less information decreases chance on repair
	Negative stigma attached to repair	Negative stigma decreases chance on repair
Repair aspects	Quality of repair /Endurance (of repair)	High quality/endurance increases chances on repair

Dimension	Repair influencce	How it influences self-repair
Repair aspects	Repair time	High repair time decreases chance on repair
	Reversibility (of repair steps)	Reversibility increases chance on repair
	Accessibility of materials & methods	High accessibility increases chance on repair
Product aspects and performance	Repair likelihood for different product types	Depends on appliance, for dishwashers the chance is on the high end (chapter 3.1.3)
	Deterioration	High deterioration decreases the chance on repair
	Functional value	High functional value increases chance on repair
	Condition of the product	Bad product condition decreases chance on repair
	Design issues (irreversible bonds)	Presence of irreversible connectors decrease the chance on repair.
	Lack of spare parts or repair tools	Access to software for diagnosis increases chance on repair
	Lack of access to software for diagnosis	Access to software for diagnosis increases chance on repair
	High quality	High quality increases chance on repair
Relationship user and product	Higher attachment stimulate repair	Higher product attachment increases the chance on self-repair.
	Repair increases attachment	Executing self-repairs increases product attachment
	Positive/negative prior experiences	Positive emotions during and after performing a self-repair increase the chance on a self-repair

Dimension	Repair influencce	How it influences self-repair
Everyday life settings of repair	Integration into everyday life	High integration into everyday life increases the chance on repair
	Convenience of repair	Higher convenience increases the chance on self-repair
	Complexity of practicing repair	High complexity decreases the chances of self-repair
	Missing repair services leads to perception broken products have no value	Missing repair services decreases the chance on repair
Warranties	Extended product warranties can lead to more repair activities	While warranties are important for stimulating repair in general, they do not guarantee an increase in the chance on self-repairs, in fact the opposite is true (chapter 4.3)

12.2 Appendix II. Extensive list of practical repair tips

12.2.1 Safety & preparation

- Always unplug the appliance before starting.
- Remove rings, bracelets, watches, and other jewellery before beginning a repair, to protect both yourself and your valuables.
- Wear gloves to protect against sharp edges (e.g. punched steel wheels or panel edges).
- Be careful with for standing water, dry it out before working.
- When a dishwasher is uninstalled and the door opens, it may tip forward; be careful with stability.
- Check that the inlet and outlet hoses aren't bent or pinched during reinstallation.
- Make sure adjustable legs are properly adjusted so the appliance sits level again after reinstalling.

12.2.3 Tools & equipment used by professionals

- Lifting table: A height-adjustable lifting table used by mechanics to safely lower stacked appliances like a washer and dryer, or to access built-in appliances like ovens.
- Air wedge: A hand pump airbag (e.g. from Action) that can tilt the appliance slightly to access the underside more easily.
- Water syringe: A big syringe to remove standing water from the appliance before continuing the repair.
- Mirror tool: Use a small mirror to inspect hard-to-see places for leaks or proper part placement.
- Angled drill adapter: A right-angle attachment for a cordless drill to access screws in tight spaces, especially at the bottom of the dishwasher.
- Flathead screwdriver: Helpful for releasing tight or hidden plastic clips.
- String trick: Attach a string to loose hoses when disconnecting them so they can easily be pulled back into place if they fall.

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- Flathead screwdriver: Helpful for releasing tight or hidden plastic clips.
- String trick: Attach a string to loose hoses when disconnecting them so they can easily be pulled back into place if they fall.The control board (PCB) is often not consumer-friendly: connections can be fragile and hard to reach, especially when located deep inside the door.
- Some components (e.g. rubber hoses) may be colour-coded to show if they've been replaced before (e.g. lighter-coloured replacements).
- Always check hose routing during reinstallation, ensure they're not kinked or twisted.
- Access and part layout can vary significantly between dishwasher models, even for the same brand.
- Some front-facing components can be replaced without fully uninstalling the appliance, but space constraints can make it fiddly.

12.3 Appendix III. Creative session planning

Creative session planning

Activity	Time	Short description	Needed materials
Prologue	5 min	Time to read, ask questions about and fill in informed consent forms & personal introduction	Printed informed consent forms
Introduction	10 min	I present my project including: context, focus, design goal and interaction vision. Time for questions afterwards	PowerPoint presentation
Repair stories	7 min	Participants get time to think about the last thing they repaired at home. Then they think about what they used to aid in their repair (tools, spare parts, documentation, videos assistance from someone else, lights, cleaning). After that they quickly share their experiences.	-
Icebreaker	7 min	Icebreaker activity to get into a brainstorming mindset and learn how to build on each other's ideas (drawing activity)	Pens/markers, 1 a4 sheet per person
Problem in short	1 min	Show the problem in short so all participants have it in their minds correctly	-
How-to prep	20 min	First 4 steps of the DDG How-to part are done in group setting	How to sheets, A3 sheet per how-to
Do how-tos	25 min	Every How-to is done collectively until now ideas come any more	A3 sheets with how-tos and post-its
Plenary retrospection	10 min	Every sheet is looked over again as a group and people get a final chance to add ideas if they want to	Post it notes, pens/markers
Group closure	2 min	Every participant quickly gets a chance to mention their favourite idea. Tell them they can reach out to me whenever they have suggestions or questions	-

12.4 Appendix IV. Harris profile criteria

Indication of why the chosen requirements are important for the chosen intervention

Intervention 1

Requirement	Why it is important
1. Use of the design involves a minimal learning process	At the replacement prevention stage, the goal is to influence users before their dishwasher breaks down. If the intervention (such as a calendar, app, or game) is complicated to learn or use, users will be discouraged from engaging with it. To be effective at this early stage, the design must be immediately accessible without requiring significant effort or instruction.
2a. The interaction with the design follows the formulated interaction quality: casual	Replacement prevention efforts need to fit naturally into users' daily lives, without feeling heavy or demanding. A casual interaction style ensures that users are more likely to absorb the information and develop a positive association with the idea of repair, rather than feeling burdened or lectured.
2c. The interaction with the design follows the formulated interaction quality: convenient	If engaging with the intervention feels inconvenient, for instance, requiring too much time, effort, or complex steps, users will be unlikely to use it regularly or at all. Convenience is key to making sure the repair-positive mindset is planted early, with minimal friction.
11. The design is engaging	Simply presenting information is not enough to change users' future behaviour. The design needs to be engaging so that users not only pay attention but also remember the message about repair as a viable and attractive alternative to replacement when a breakdown eventually occurs.
10. The design ensures users will feel that their skills are adequate before and during the repair.	Even at the replacement prevention stage, users form early impressions about whether self-repair seems "doable" for them. The design should plant the idea that repairing is within their abilities. This boosts their self-efficacy early, making it more likely they will choose repair over replacement when the time comes.
4. The design uses clear language, visuals, and interactive elements	Clarity is crucial at this early influence stage. If the information is confusing or overwhelming, users will dismiss it and stick with their existing habits (e.g., replacing instead of repairing). Clear, supportive communication builds understanding and openness to self-repair.

Intervention 2

Requirement	Why it is important
14. The design guides users in identifying the issue accurately, without the need for external assistance.	Fault diagnosis is often where consumers get stuck and give up. If users need to seek extra help, the hurdle becomes too high, and they are less likely to continue to a self-repair. A clear, autonomous fault diagnosis process is therefore important to get users further in the repair.
1. Use of the design involves a minimal learning process	Users must be able to understand and use the fault diagnosis tool without needing significant instruction. If the tool is confusing or takes too long to learn, users may become frustrated and abandon the repair attempt altogether.
2d. The interaction with the design follows the formulated interaction quality: intuitive	Diagnosing faults should feel natural, not like navigating a complicated system. An intuitive process minimises user errors and builds confidence from the very start of the repair journey.
2b. The interaction with the design follows the formulated interaction quality: comfortable	The experience of diagnosing an issue should not be stressful. If users feel rushed, confused, or overwhelmed, their motivation to repair will decrease. A comfortable interaction ensures that users remain calm and willing to proceed.
17. The designed fault diagnosis and instruction solution are interesting to use.	Fault diagnosis can easily become a tedious or dry experience. If the process is designed to be engaging or interesting, users are more likely to complete it and move on to the repair phase. It helps sustain motivation throughout the task.
4. The design uses clear language, visuals, and interactive elements	Clear communication is critical during fault diagnosis. Technical jargon, unclear visuals, or complicated instructions can confuse users and cause mistakes in identifying the issue. Simple and effective communication supports accurate and confident diagnosis.
8. The design communicates a repair summary, estimated cost, and repair time range after the fault diagnosis and before the actual repair.	After diagnosing the problem, users need to understand what they are committing to. Clear communication about costs, expected time investment, and repair complexity helps users make informed decisions and builds trust in the process.
3. The design integrates solutions for common practical challenges, such as obtaining the required tools, access to repair manuals and instructions, and ordering replacement parts.	Diagnosing a fault is only useful if the next steps are accessible. Users should be seamlessly guided to the tools, manuals, and parts they need.

Intervention 3

Requirement	Why it is important
15. The design provides clear, structured repair instructions.	Clear and structured instructions are essential to prevent mistakes and confusion during repair. Users are likely unfamiliar with the repair process, so having a well-organised, step-by-step guide increases their confidence and likelihood of completing the repair successfully.
16. The design presents the repair instructions in an interactive and visual way.	Many users learn better visually or through interaction rather than only reading text. By making the instructions interactive and visual, the repair experience becomes more understandable, engaging, and less intimidating, especially for less experienced users.
1. Use of the design involves a minimal learning process	At this stage, users should not have to spend time figuring out how to access or navigate the repair instructions. They should be able to focus entirely on the repair task itself. A minimal learning curve ensures the tool truly supports the repair process rather than becoming an additional barrier.
2a. The interaction with the design follows the formulated interaction quality: casual	A casual interaction style makes the repair feel less formal, rigid, or intimidating. It puts users at ease, making them feel like small mistakes are acceptable and that the repair is achievable for them.
2b. The interaction with the design follows the formulated interaction quality: comfortable	If users feel stressed, overwhelmed, or pressured, they are more likely to quit halfway. Comfort during the instruction phase ensures users stay calm, confident, and persistent.
2d. The interaction with the design follows the formulated interaction quality: intuitive	Repair instructions should feel logical and self-explanatory. If users can naturally understand the next steps without constantly needing to double-check or guess, it prevents frustration and builds flow and confidence during the repair process.
17. The designed fault diagnosis and instruction solution are interesting to use.	Repairs can be tedious or tiring. If the instructions are presented in a way that feels interesting users are more likely to stay motivated and finish the repair.

Scoring rubric

-2	The design does not meet the criterion at all. Significant shortcomings are present. User understanding, engagement, or usability is strongly hindered.
-1	The design partially meets the criterion. Some aspects are addressed, but notable gaps remain that could cause confusion, frustration, or reduced effectiveness.
1	The design mostly meets the criterion. Minor improvements could be made, but overall it supports user needs effectively without major obstacles.
2	The design fully meets the criterion. It strongly supports user needs and expectations, contributing positively and seamlessly to the repair experience.

12.5 Appendix V. Test plan first test

12.5.1 Calendar

Scenario

You come home from work on a Thursday. This morning you turned on the dishwasher before you left, but the dishes aren't clean and the machine doesn't seem to have done anything at all. Than you notice that the lights in the kitchen also don't work. You check the fuses and see that one has flipped. After making sure the dishwasher is turned off you flip back the fuse and now the lights in the kitchen work again the. You think about what could be the problem but realise that you actually don't know anything about how dishwasher work. Googling the problem doesn't give a clear result. ATAG has some common problems listed on their website, but this problem isn't included. The site tells you to plan a service visit for which you have to email and the mechanic will take a week or longer to come round.

Likert scales

-3 -2 -1 0 1 2 3

- How likely is it that you would go and try to fix this problem yourself?
- How likely is it that you would call ATAG service for them to fix the problem for you?
- How likely is it that you would go online and order a new dishwasher right away?

Repeat after calendar has been seen.

Questions

- How likely is it that you would hang the Calendar in your house (somewhere in a location where they can see it daily)?
- Did your attitude about repairing change after seeing this calendar?
- What about it changed your mind (if anything)?
- What would make this more convincing?
- What would you remove/add?
- Ask testers after testing the other concepts if they remember any key facts or messages.
- Do you have a birthday (or different) calendar containing information yourself? what can you remember about it?

12.5.2 Fault diagnosis

Scenario

In the end, you did decide to try and repair the problem yourself. You don't want to do the dishes by hand for that long and you can only reach ATAG tomorrow morning. Carefully you turn the dishwasher back on, and you see the error code F68. While looking on the ATAG website to make a service appointment, you found a troubleshoot/ fault diagnosis help, which you decided to give a try. You are prompted to enter your error code which you do and you see the following screen.

Questions

- How did you like the process of fault diagnosis using this method?
- Are you more likely to self-repair after knowing what is wrong?
- Did this process take a lot of effort?
- Did the use/look of this prototype feel familiar?
- Did you understand the prototype right away?
- What changes would you make to the design?
- How would you have done the fault diagnosis if it wasn't for this prototype?

12.5.3 AI assistant

Prototype script

Introduction

"Hello! I'm your repair assistant. I'll guide you step by step to replace your dishwasher's drain pump. I'll keep things simple, and you can ask for help, any time. If you don't understand something I can repeat the step or I can show you a visual to help you understand. Ready to get started?"

tep 1: Safety First

"First, let's make sure everything is safe. Please unplug your dishwasher from the power."

Step 2: Needed materials

"Let's also check if you have all the required tools and materials for this repair. Do you have a torx 20 screwdrivers, a flat head screwdriver, the spare part and a small bowl or tray to your screws in?"

Step 3: Accessing the Drain Pump
"Now, let's get to the drain pump. First remove the bottom front panel of the dishwasher. This is a small metal plate located underneath the door. It is held in place with 4 screws. Can you see them? (If the user needs help, provide a visual.)
Remove these with the torx20 screwdriver and keep them safe in your bowl.
Then carefully remove the panel. It is hooked at the front, so you need to lift it up and tilt it towards you to take it out. Before pulling it out completely, disconnect the ground wire on the upper left side of the metal panel"
(Wait for removal.)
"I can see that you are finished with removing the panel, let's get to the next step."

Step 4: Identifying the Drain Pump
"Now, you can see the drain pump right in front of you slightly right of the middle, can you point to it? Correct that's it"
(If needed, provide a visual)

Step 5: Disconnecting the Old Pump
"Before taking out the pump, first unplug the wires by simply pulling on the white block that the black wires are attached to. To take out the pump turn it counter clockwise and pull it out. But be careful it is attached with a small snap joint, you might need to lift this up a little bit. Just take your time and don't force anything."

Step 6: Installing the New Pump
"Now, let's put in the new pump! Position it the same way as the old one, and secure it by turning it clockwise. Make sure the snap joint is secured correctly in place. Now feel around the edge of the pump you just put in to make sure that there are no gaps between the pump and the pump chamber, otherwise it will leak when running the dishwasher."
That looks good! Now reconnect the wiring harness again. It can only go in one way, so don't try to force it, if it doesn't fit. Before testing we also need to re attach the ground wire to the metal panel, but don't put the panel back yet.

Step 7: Testing the Repair
"Now, let's test your repair. Plug in the dishwasher and turn on the water supply.
Run a short rinse cycle and check for leaks. If everything stays dry at the bottom and the dishwasher is draining properly, you've successfully replaced the pump!"

Step 8: Wrapping Up
"Great work! Now, turn the dishwasher off, unplug it again, and reattach the metal panel. The easiest way to do this is to put the top part in place first and then push the bottom towards the machine to engage the snap joints. Then just put the screws back and you're all set!"

Questions
- How did you like the process of repairing using this method?
- Would you like to use this again when repairing something?
- Where the visual aids useful for the repair?
- How did you like the personality of the voice assistant?
- What personality would you like to see/hear in an AI assistant like this?
- Do you feel like you could/would have done this quicker if you used 'regular' written instructions with text and pictures?
- What changes would you make to the interaction?

Questions about whole session
- Did you enjoy the whole process (all 3 tests) / was it fun?
- What was the most/least fun?
- Did this process take a lot of effort?
- Did you need to get used to the methods?
- How do you feel after completing this whole process?
- What do you remember about the calendar?
- Did you understand the prototype right away?

12.6 Appendix VI. Final evaluation test plan

12.6.1 Research goal

The main goal of this final user test is to evaluate the user experience and overall usability of the IRIS prototype.

This evaluation focuses on how well the prototype aligns with the previously defined design requirements and intended interaction qualities (casual, comfortable, convenient, intuitive). Attention will be paid to how users interact with the assistant, including the clarity and helpfulness of the visuals used throughout the repair process. The perceived personality of the AI assistant will be assessed to understand how it influences user confidence and satisfaction.

12.6.2 Method

12.6.2.1 Set-up

Evaluations will take place over multiple session ove multiple days. Each session is divided into three parts and will take about 60 minutes in total.
- Part 1: Introduction (10 minutes)
- Part 2: repair (30 minutes)
- Part 3: post-test interview (20 minutes)

During the session, the researcher will play the role of AI assistant while a camera records the repair part.

Figure 45 shows the top down set-up of the evaluation sessions.

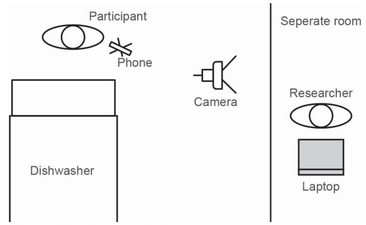


Figure 45. Top down evaluation session set-up

The participant receives a phone that is on a video call with the researcher's laptop. The researcher is set up in a different room, where they can't see the dishwasher or the participant. This way, the role of IRIS is better imitated since the researcher can only see what the participant is doing via the phone camera. Voice instructions are also given via the phone's speaker.

12.6.2.2 Participation Criteria

Dishwasher owners spread age and gender. Repair experience is not selected on since the prototype should work for all people with different repair experiences, but it is asked about in the test to refer to with the evaluation results.

12.6.3 Test flow

12.6.3.1 Introduction

Goal: introducing the session plan and the product, and getting the participant's background information

At the beginning of each session, participants will be informed about the research methods (camera-voice recording, interviews, etc.), and their consent will be taken. Following that, a small structured interview will be conducted with each participant to obtain their background and experience with repairing. This first part will take approximately 10 minutes.

Introduction script:
Thank you for joining this product evaluation today. We will start by signing the consent form. It concerns permission to record the session; the footage will only be used for academic purposes.

In this session, you will be using a new form of repair instructions. It is an AI-voice assistant called IRIS, which will guide you through the repair based on voice commands. I will explain it later on in more detail. During the session, you can ask any questions you

have at any time, and you are free to end the session if you feel uncomfortable at any time. I want to remind you that I am not testing you as a user, but testing the product only, and there is no right or wrong answer/action for any tasks. Additionally, you don't have to worry about damaging the dishwasher in any way; it is only a test model.

The session will take about an hour. First, I will ask you a few questions about your repair experience. Then, you will execute a dishwasher repair using the prototype. Lastly, we will finish with a short interview about your experiences. Now, we will start with a few questions.

Pre- repair interview questions:
- Have you ever repaired something? What? When? How did you do it? Did it go well?
- What repair ability score would you give yourself? (Likert scale 1-7)

12.6.3.2 Repair
Goal: having the participants execute a repair using the IRIS prototype

IRIS explanation
Now you are going to do the repair. I will first explain the prototype and then give you a scenario
IRIS explanation points:
- AI assistant
- Conversational
- You can ask it questions
- Iris sees what you are doing via the camera and might correct you if something is wrong
- Sometimes the camera might need to be adjusted to help IRIS see better
- In addition to sound, IRIS can also show you visuals to help you better understand certain repair situations; these will be visible on your phone screen.

It is important to note that there is not a real AI assistant, but the researcher will act out this character. They are still only able to see, hear, and give voice commands via the phone.

Scenario
Some time ago, you noticed that your dishes weren't fully clean after using your ATAG dishwasher, and there was also a slight smell coming from it. You looked online and you found an ATAG fault diagnosis program. You decided to try it and discovered that your soap dispenser needs to be changed. It linked you to their webpage where you can order spare parts. You ordered the spare parts, the necessary tools for the repair, and the recommended safety equipment. When the box arrived, there was also a note that suggested installing the ATAG app so you can use the new IRIS repair help. You downloaded the app and planned a time to do the repair.

12.6.3.3 Post-repair interview
The goal is to gain insight into the respondent's overall opinion and perception by questioning participants about the specific elements of the design and evaluating the presence of the defined interaction qualities.

Quantitative questions:
Likert scales (1-7) on interaction qualities:
- Casual
- Comfortable
- Convenient
- Intuitive

Qualitative questions:
General
- How did you experience the repair using this method in both a positive and a negative sense?
- Was there anything in particular that stood out to you?
- Were the step-by-step instructions clear and easy to follow? Why or why not?
- Did you feel engaged while using IRIS during the repair?
- Did you feel your skills were adequate during and after the repair?

Visuals
- Where the visuals clear? Did they help you understand the situations better?
- What improvements in the visual aids would help you understand better?

Voice
- What did you think about the voice commands in both a positive and negative sense?
- What did you think about the small corrections from the voice assistant?
- Did IRIS help you feel confident in your ability to complete the repair?

IRIS' character
- How would you describe the character?
- What did you think of the character?
- What personality traits would you like to see in Iris' character?

Finishing
- Would you like to use IRIS again for future repairs?
- Do you see any improvement points for this concept that we haven't discussed yet?
- We have reached the end of this interview. Is there anything you would like to share about this test/prototype?

12.6.4 Script
12.6.4.1 Repair script
Introduction
Hello, my name is IRIS. I'll be guiding you through replacing the soap dispenser in your dishwasher. I'll talk you through each step and show you helpful visuals along the way. To be able to do this well, you need to set up your phone in such a way that I can see the repair via your camera; you can use the tripod for this. Good. In this repair, you'll replace the dishwasher's soap dispenser. It involves removing the door panel, disconnecting the old dispenser, installing a new one, and reattaching the components. Now for the safety measures.

Step 1: safety first
Before we start, please make sure the dishwasher is unplugged and you have free space in front of the machine. This repair has a low risk of material damage but a medium risk of accidentally cutting yourself, so remove all your jewellery from your hands and put on protective gloves. We are going to be working with some metal parts that might be sharp. Are you ready?
Now let's check if you have all the necessary tools, do you have a torx 20 screwdriver, a small flathead screwdriver and a small bowl or tray to store the screws in?

Step 2: remove screws from the door
Open the dishwasher door fully. You'll see a series of screws on the edge of the door.
Let's start by removing the 6 screws that secure the large metal plate. Don't worry about remembering where each screw goes I'll help you with reassembly later. Remove them in the order you can see in the image.

[Visual: Screw remove order, Figure 46.1]

Important: When you're down to the last two screws, support the metal plate with your hand so it doesn't fall and damage anything.

Note: We're intentionally leaving two screws in place to keep the control panel attached. This way, it stays out of your way during the rest of the repair.
You can set the large metal plate aside; we don't need to do anything with it until reassembly.

Step 3: locate and disconnect the soap dispenser
These next few steps are easier with the door closed, so go ahead and press the door into the lock. You'll see the soap dispenser in the middle of the door; it's the translucent plastic component.
Start by removing the flexible translucent plastic protection cover and place it to the side.
Next, disconnect the two cables attached to the soap dispenser. The right-hand cable simply pulls out, while the left one is held by a small snap fit. Use a small flathead screwdriver to gently lift the snap tab, then pull the cable out. There is no need to remember which cable goes where; I can help with that during reassembly again.

[Visual: Close-up of snap fit and screwdriver position, Figure 46.2]

Step 4: remove the soap dispenser
The dispenser is held in place by 10 small metal snap fits around the edge.
Use your flathead screwdriver to pry each one open. Slide it under a metal snap fit and twist to release each tab. These metal tabs

do not break easily, so you can apply force if needed. It's okay if they bend a little; that is necessary to remove the soap dispenser. You will bend them back at a later stage.

[Visual: Screwdriver under metal tab, Figure 46.3]

Once all the tabs are loosened, tap the back of the dispenser gently with your hand to release it.
Now open the door again and slide the dispenser out from the inside.
If it's not coming out easily, one of the metal tabs may still be in the way. Pry it open a little more, and you can try again.

Step 5: prep the opening
Before installing the new soap dispenser, bend the metal tabs slightly inward.
Be careful, these edges can be sharp.

[Visual: Correct bend distance: 0,5 to 1 cm, Figure 46.4]

Step 6: install the new soap dispenser
Now, you are going to press the new soap dispenser into place from the inside, but make sure it's the right way up. The lettering text on the front of the new soap dispenser should be upside down. If you are not sure about the orientation, you can also refer to the image.

[Visual: Correct orientation, Figure 46.5]

If needed, press the metal tabs slightly back against the frame. Each tab should lock into place in one of three small notches. The closer the metal tab is to the middle notch, the better.

[Visual: Step structure for snap fits, Figure 46.6]

To do this easily, close the door again, slightly pull on the soap dispenser, and press on the metal tabs. Then, try to move the dispenser around to check that it is secure and not wobbling. If there is no movement, it is correctly in place.

Step 7: reconnect cables and cover
Reconnect the wires to the soap dispenser. The white plug with 4 brown wires goes on the right.
The one with 2 brown wires goes on the left. The plugs only fit in one way, so don't force them if it doesn't go on easily
Now, reattach the protective film to the back of the dispenser, according to the image

[Visual: Correct film placement, Figure 46.7]

Step 8: reattach the metal plate
Now you are going to reattach the metal panel to the door.
Tip: It might be easier to sit in front of the dishwasher with the door halfway open and rest the plate on your knees. You can also sit on a chair and rest it on your knees.

Do you see that you have 3 different types of screws. We will first need the short ones with a pointy tip. Can you see them? Okay, let's start. First take a look at the image to know where these screws need to go. Slide the metal plate back into place using the notches on the black plastic part. Then screw in the short pointy screws in the right order. Once 2 screws are in place you don't need to hold the plate anymore. Now you can insert the remaining screws according to the image.

[Visual: Correct screw positions, Figure 46.8]

Step 9: finished
Well done! You've successfully replaced the soap dispenser.
Great job repairing this yourself, you've just extended the life of your dishwasher and saved yourself a service call.

12.6.4.2 Optional sentences
(to correct the user in case of mistakes.)
1. "It looks like that part hasn't been fully detached yet, try loosening the remaining metal tab on the left side before removing it."
2. "Careful, those cables aren't meant to be pulled forcefully. Let's take a closer look at the release mechanism together."
3. "You might be trying to remove the wrong screws. Let's double-check the ones I highlighted earlier."
4. "That angle might make it tricky. Try positioning your screwdriver slightly lower and gently twisting; it should release more easily."
5. "Hmm, it seems like the new dispenser isn't sitting flush. Could you press it in evenly from both sides and make sure the tabs align with the notches?"
6. "Just a heads-up, the plate looks like it's being reattached upside down. Let's flip it and try again."
7. "Don't worry, it happens! Let's pause and go back a step to make sure everything's in the right place before we continue."
8. "Let's take a quick moment to double-check that step. Sometimes, a small adjustment makes all the difference."
9. "No worries, this part can be a bit tricky. I'll guide you through it again, step by step."
10. "That doesn't look quite right just yet, let's pause and make sure everything's lined up the way it should be before moving on."

12.6.4.2 Script visuals
1. Screw remove order
2. Close-up of snap fit and screwdriver position
3. Screwdriver under metal tab
4. Correct bend distance: 0,5 to 1 cm
5. Correct orientation
6. Step structure for snap fits
7. Proper film placement
8. Correct screw positions

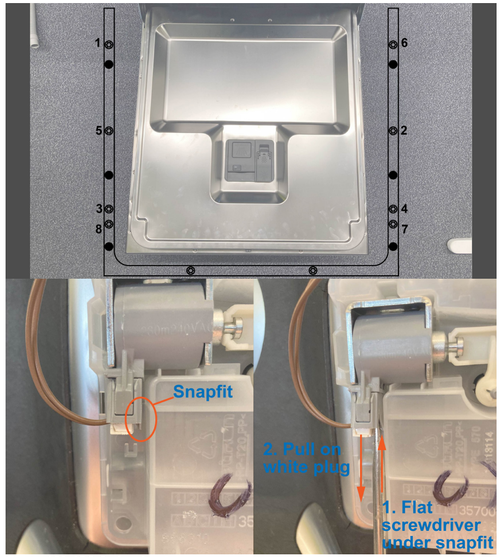


Figure 46.1, 46.2. Script visuals

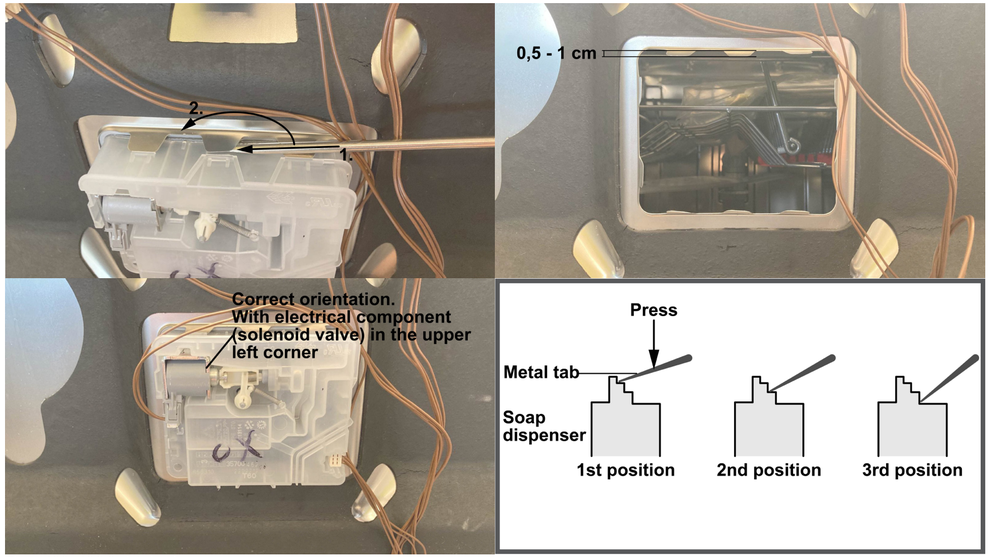


Figure 46.3 - 46.6. Script visuals

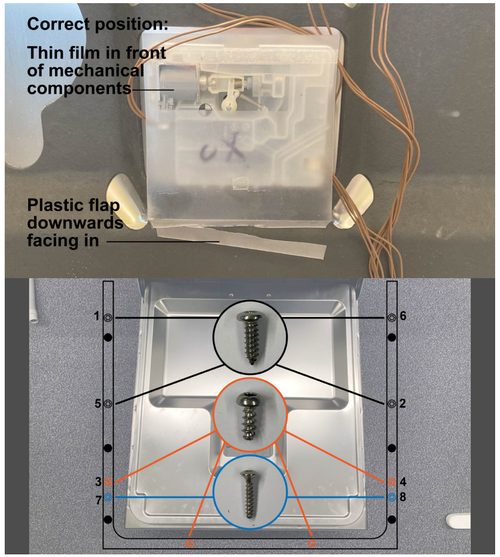
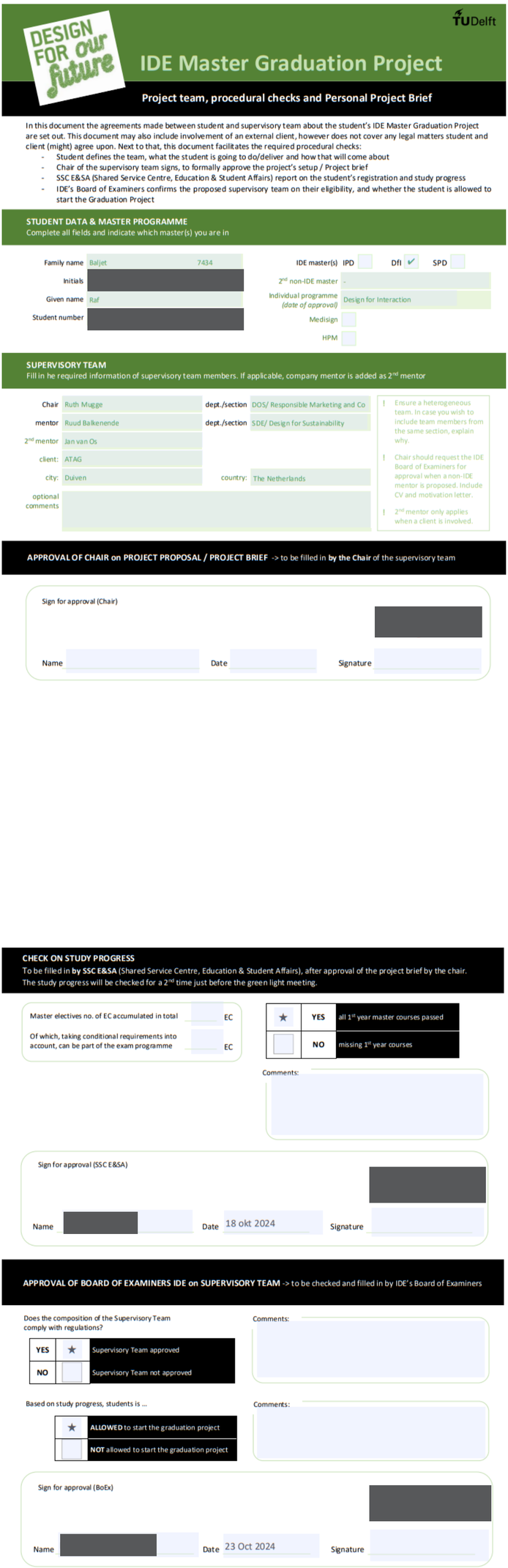


Figure 46.7, 46.8. Script visuals



TU Delft

DESIGN FOR our future

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

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

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

STUDENT DATA & MASTER PROGRAMME

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

Family name	Baljet
Initials	[redacted]
Given name	Raf
Student number	[redacted]

IDE master(s)	IPD ☐ Dfi ✔ SPD ☐
2nd non-IDE master	-
Individual programme (date of approval)	Design for Interaction
Medisign	☐
HPM	☐

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Ruth Mugge	dept./section	DOS/ Responsible Marketing and Co
mentor	Ruud Balkenende	dept./section	SDE/ Design for Sustainability
2nd mentor	Jan van Os		
client:	ATAG		
city:	Duiven	country:	The Netherlands
optional comments			

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

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

Sign for approval (Chair)

[redacted]

Name _____ Date _____ Signature _____

CHECK ON STUDY PROGRESS

To be filled in by SSC E&SA (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total _____ EC

Of which, taking conditional requirements into account, can be part of the exam programme _____ EC

★	YES	all 1st year master courses passed
☐	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

[redacted]

Name [redacted] Date 18 okt 2024 Signature _____

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO	☐	Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	ALLOWED to start the graduation project
☐	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

[redacted]

Name [redacted] Date 23 Oct 2024 Signature _____

DESIGN FOR our future

TUDelft

Personal Project Brief – IDE Master Graduation Project

Name student Raf Baljet **Student number** [redacted]

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT
Complete all fields, keep information clear, specific and concise

Project title Designing an intervention to increase the number of self-repairs amongst users of ATAG kitchen appliances

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

Introduction

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

The amount of e-waste only keeps increasing. In 2018 we threw away 6,8 kg of e-waste per person worldwide, while this was 5,0 kg in 2010. In 2014 the EU generated 11,6 Mt of e-waste (Baldé et al., 2015) among which scarce materials like precious metals (Arya & Kumar, 2020). In addition to the waste, it takes a lot of energy to make these electronic products. The best way to make these products have less impact on the environment is to use them longer (Truttmann & Rechberger, 2006), with which repairing can help.

The EU recently passed the right to repair bill, roughly stating that manufacturers are obliged to repair (within a certain time frame). Spare parts, tools & documentation have to be available to users and third party repair services. Also, an online platform will be created and repair incentives (Right To Repair: Making Repair Easier And More Appealing To Consumers | News | European Parliament, z.d.). Complying with this legislation as soon as possible makes sure that even the products that are not yet on the bill are ready for when they eventually get added. It also creates the opportunity to create a more sustainable brand image among the general public.

The users can benefit from longer lasting products, better spare-part availability and lower repair cost and the world will benefit from a reduction in (e-)waste.
Limiting factors might include that ATAG mostly focus on kitchen appliances, part of which are not included in the right to repair bill (*Right To Repair - Partners For Innovation*, 2024).
Also, because of surrounding panelling, built in appliances are also more difficult to service than their non built in counterparts.

→ *space available for images / figures on next page*

introduction (continued): space for images

Question	Method	Result
On which product(group) should I focus?	Interview ATAG, product overview, literature	Focus
What motivates people to repair their own products?	Literature, interview user	Design requirements, target group
How can I make the repair experience as comfortable as possible?	Literature, interview user, co-creation, tests	Design requirements
How can I make the barrier to repair as low as possible?	Interview user, co-creation, tests, literature	Design requirements
What do users need to repair their own products?	Interview user, co-creation, tests	Design requirements
What happens with a product after it has been repaired? (how long will it still be used? Is it trusted not to break again? Will it be used as much as before?)	Interview ATAG, literature	Design frame
How do people feel while repairing their appliances?	Interview user, emotion scan	Overview of emotion and feelings → points were to intervene
Why are certain things repaired often (cars, washing machines) and some things not so much?	literature	Understanding of repair motivations
What do users think to need so they can repair their own products? (self-reported)	Co-creation, interview user	Design requirements
How do people differ in how far they are willing to go to repair their own products? / What is the scale of repair willingness?	Interviews, literature, Context mapping, persona	Design requirements, repair possibility scale
Which products does ATAG (, Pelgrim, ETNA, Hisense & ASKO) sell?	Context mapping	Overview of products
What is the scale of repair complexity of executed repairs (maintenance to specialist jobs)?	Interview repairers, Context mapping	Repair complexity scale, focus
What is the scale of home repairers? How far are they willing to go?	Interview user, context mapping, Persona	Repairer scale
How can the repair experience be made as "pleasant" as possible?	Interaction vision	Interaction qualities
How can I change a negative repair experience into a positive one?	Rich experiences	Design direction
How are ATAG products being used now? (For how long are they used? Are they being repaired? Solid second hand?)	Context mapping, product journey mapping	Product/company understanding, view into current situation

image / figure 1 Table with overview of questions & methods

image / figure 2

DESIGN FOR our future

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Personal Project Brief – IDE Master Graduation Project

Problem Definition

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

As mentioned before, repair is a great way to prolong a product's lifetime. The problem for ATAG is that this is not done by consumers themselves. Because of this ATAG has to spend time and resources on service calls for customers with broken products that they'd rather spent elsewhere.
The main problem to solve is that consumers don't repair their own kitchen appliances at home. Within this there are a few sub problems, people don't consider having their broken products repaired, they think they don't have the necessary skill and users discard/replace their products too quickly (McCollough, 2019). Being able to motivate the users is key, since the repair is dependent on their willingness to put in the time and effort(Terziolu, 2021). This becomes particularly important as the focus of this project is on the users repairing their broken appliances themselves (self-repair).
Because the focus is on self-repair ATAG could create added value and differentiate themselves from their competitors by offering in depth repair help, creating a better brand image and selling spare parts. Outside of the user it would also help ATAG reduce the number of service calls. Self-repair would also help improve the user-product attachment and brand loyalty (McLaren et al., 2020; Van Der Velden, 2021). Additionally, users repairing their own broken appliances would afford them a quicker and cheaper repair, as well as a better understanding of their product.
According to some studies (Magnier & Mugge, 2022) as much as 60% of participants do not even consider repair in cases of a malfunctioning product. This means that getting those people to repair their own products will be difficult. However, by

Assignment

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

Design an intervention to increase the number of self-repairs amongst users of ATAG kitchen appliances at home.

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

To find out which methods to use I made an overview of research questions I want answered, which methods I can use for that and what kind of result I will get from it. The table can be found in figure 1 on the previous page.
I will start my project with an analysis phase, within in this phase I will first discover: gather information with literature research, interviews and an emotion scan. After that I will structure this information in the define phase, by means of a persona, design goal, interaction vision, a small context map and product journey map.
In the explore/ideate phase I will focus on finding solutions (ideation, co-creation, rich experiences) and testing these solutions. This will not be an exact split, but both processes will happen simultaneously with more of a focus on finding in the beginning and testing in the end. Finished with picking ideas.
During the validation phase these will be prototyped and tested first during the testing part and in the analysis part the data will be used to draw conclusions and formulate recommendations.
The finalise phase will first be focussed on reporting and afterwards on the final presentation.

Project planning and key moments

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

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

Kick off meeting	21 Oct 2024
Mid-term evaluation	16 Dec 2024
Green light meeting	24 Feb 2025
Graduation ceremony	24 Mar 2025

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

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:
Christmas holiday
23/12 - 05/01

Motivation and personal ambitions

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

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

I have a great interest in repair and love doing it myself. I know this is not the case for everyone, so helping others find their way around repairing would be very rewarding. Furthermore I have a few skills to prove and develop. I love rapid prototyping and subsequently using these prototypes to do small scale tests with, which I think will be very useful during this project. I have experience with preparing and conducting interviews, but it is a skill that I am not yet fully confident about so I want to practice it more. During my master's I have done a few cases for real companies, but never this close of a collaboration. I think this is a great skill to have, so I will be consciously involved in bringing this collaboration to a successful end, by balancing my own ideas with those of my coaches and ATAG.

There are many subjects I would like to gain in depth knowledge on during this project. One of which is the average user's attitude towards repairing. I know I am an outlier, so I want to know how a regular user feels and how I can take their preferences and desires into account.