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Article

## Design for Product Care—Development of Design Strategies and a Toolkit for Sustainable Consumer Behaviour

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### ABSTRACT

*Background:* Taking care of products is a relevant approach to prolong products' lifetimes and retain their desired level of performance, and is thus an important aspect of sustainable consumer behaviour. Although consumers have a general motivation to take care of their products, previous research has shown that they struggle to repair, maintain or treat their products carefully in daily life. Design has the potential to increase consumers' product care activities, but designers need more knowledge and distinct strategies to evoke this product care behaviour with consumers.

*Methods:* By the means of a multi-method approach—individual and group brainstorming sessions as well as an analysis of existing solutions—we created a large number of ideas on how to stimulate product care among consumers.

*Results:* We were able to summarize these ideas in a clustering session into eight strategies and 24 sub-strategies that can foster product care through design. These eight strategies are: social connections, informing, enabling, appropriation, control, awareness, antecedents & consequences, and reflecting. The integration of the consumer perspective into strategies for product care extends currently known design strategies for repair and maintenance. To support designers in the implementation of these strategies, we developed a toolkit that can be used in the product development process of different product categories.

*Conclusions:* This paper identifies product care strategies that have a distinct focus on the consumers' perspective of sustainable behaviour and that can be stimulated through design. These rather psychologically-driven strategies thereby complement existing technology- and product-oriented design strategies. Furthermore, to facilitate implementation, a design toolkit has been developed that points to key requirements in practice.

### Open Access

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**KEYWORDS:** design for sustainability; repair; maintenance; consumer behaviour; design toolkit; sustainable consumer behaviour; behaviour change

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## INTRODUCTION

Product care is defined as all activities initiated by the consumer that lead to the extension of a product's lifetime. It includes repair and maintenance, and also preventive measures, such as protective covers for smartphones, or a general careful handling of the product [1,2]. Product care is one possibility to extend the lifetime of a product, because it keeps the product in a usable and appealing state for a longer period of time, thereby postponing its replacement by new products. Product care is therefore of great relevance for addressing the environmental issues of today's consumption society because it helps to sustain materials and products, leading to fewer products that are thrown away although they could still be used. In this respect, product care supports the concept of the Circular Economy [3] which intends to "keep products, components and materials at the highest utility and value, at all times" [4]. One principle of the Circular Economy is the "power of the inner circle", which suggests that most savings can be gained by the inner loops. Strategies related to lengthening the first life of the product, such as stimulating product care, should thus be preferred over outer loops, such as refurbishment [5] and recycling [6], making product care an important topic to investigate for scientific research as well as for practice.

Product care has mostly been explored in the scientific literature through qualitative studies, such as interviews or focus groups (see e.g., [1,7,8]). The findings suggest that the tendency to perform care activities on products is dependent on the product's attributes (e.g., price, material and easy access to faulty parts), the consumer's characteristics (e.g., repair knowledge and skills) and the strength of the emotional bond between the consumer and the product [9,10–17].

With respect to the product's attributes, the product's initial price plays an important role for the likelihood to take care of a product [18], especially when the initial product price is low in comparison with the cost for product care, people are not likely to take care of the product [19,20]. In contrast, many consumers perform care activities for their cars because a car is generally a large financial investment. In general, consumers are more likely to replace products that have a low perceived value [21]. This value can be related to an emotional value but also to functional and aesthetic value. Designer should keep the product value high in order to postpone replacement and extend products' lifetimes, for example by using materials that age gracefully (e.g., with an appealing patina; [22]). Product care is another approach to keep the functional and aesthetic value of a product high because it keeps the product in a usable and appealing state.

Another product-related factor that influences the likelihood of product care activities to take place is the accessibility of the different parts that need care. Some products, such as smartphones, are designed in a way that makes them hard to be repaired and to be cared for. In the literature, the Design for Repair & Maintenance principle [23–25] has been proposed to improve product care. This principle includes design strategies that focus on (design) engineering and the technical possibilities of the product design that ease maintenance and repair, such as a product design that avoids narrow slits and holes for easier cleaning, simplified access to components that should be maintained [26], enabling the use of standard tools for opening and replacing parts, and good availability of spare parts [27].

These examples demonstrate that manufacturers can contribute to a Circular Economy by facilitating product care for their products. Fostering product care can lead to a higher brand loyalty and to an increased probability of future purchases by consumers [27,28]. In addition, recent civil movements demonstrate the growing awareness of consumers about sustainable consumption. Consumers demand manufacturers to offer more sustainable products—and also products that allow them to consume in a more sustainable way. As an example, the Right to Repair movement is fighting for legal actions by the government in several countries to ease repair for consumers. As a consequence, the European Union launched a “right to repair” directive in October 2019 [29,30]. By 2021, the directive that requires manufacturers to design for longer product life and to make spare parts available for up to 10 years, will empower consumers to take care and repair their products. In addition, EU-funded projects such as the PROMPT project (<https://prompt-project.eu/>) focus on the assessment of consumer products’ lifetimes, which may indicate the political relevance of this issue.

At the moment, the design strategies that foster product care focus on the product itself, and generally ignore the role of the consumer, thereby more or less assuming that consumers will do these care activities spontaneously. Enabling repair and maintenance via the product and its design is an important requirement for extending product lifetimes, but these strategies will not contribute to a Circular Economy if consumers are not motivated to initiate care activities on the product in the first place. Only if consumers actually conduct repair and maintenance activities on the product, this may positively influence its lifetime. Product care thus heavily relies on consumers’ behaviour once the product is in use.

In the literature, this important role of consumers for conducting product care activities has been recognized [31]. Specifically, it is found that consumers’ knowledge and skills related to product care can stimulate care activities being executed on products. However, too often the necessary knowledge and skills are missing and consumers are not inclined to initiate maintenance or repair activities [7,8]. As a consequence, many products are prematurely replaced [21], thereby

creating an environmental burden of today's consumption. Although past research has concluded that consumers recognize the need to take care of their products, they often fail to include these activities in their daily lives and/or are reluctant to execute these activities [1]. As a result of this value-action gap, consumers do not make optimal use of many products' potential lifetimes [1,32], thereby retaining a less sustainable way of consumption. Prior research has proposed that the design of products and services can be a valid approach to achieve a behaviour change among consumers [33–35]. However, thus far knowledge on how design can successfully encourage consumers to initiate and execute these care activities on their product is lacking, even though this knowledge is pivotal for moving towards the Circular Economy. This paper aims to address this gap in the literature. We contribute to the research on product care by answering the following research questions: (1) What are possible design strategies to stimulate consumers to initiate and conduct product care activities? and (2) How can the design strategies for product care be transferred into design practice?

This research contributes to the scientific knowledge on product care by uncovering design strategies that take the consumers' perspective to product care, by focusing not only on the facilitation of product care but also on the necessary sources of motivation to take care and on possible triggers to activate the care process at the right time.

Our research also has value for industry and design practice. While there are toolkits for designers that focus on designing for behaviour change in general, such as the Design for Intent toolkit [36], a toolkit that supports the design for product care from a consumer perspective is lacking. Specifically, we contribute to practice by developing a new and efficient design toolkit that puts the uncovered knowledge on the identified design strategies for the consumers' perspective on product care into practice. Designers and (NPD) managers can use this Product Care Kit in their design process to encourage consumers to take care of their products. Prior research on toolkits has used categorizations of large sets of relevant product examples or principles coming from desk research and workshops [36–38] as the research methodology to uncover significant design strategies. Correspondingly, our research will use a combination of desk research and workshops to distill design strategies for product care.

## **THEORIES FOR BEHAVIOR CHANGE**

Design has the potential to stimulate a more sustainable form of consumer behaviour. Our research essentially builds on two models for behaviour change. The first model is Fogg's behaviour model [39] that states that for a behaviour to occur, motivation (if people want to do it), ability (if people can do it) and triggers (stimuli that provoke people to do it) have to be present at the same time.

Motivators in this model are pleasure, hope, or social acceptance, as well as the corresponding negative aspects of pain, fear or social rejection.

Pleasure or pain are immediate reactions to a situation. For example, when a person enjoys riding his/her bike, he/she will be motivated to repair it when it breaks down because repairing the malfunctioning bike will enable him/her to experience the enjoyment again. On the other hand, hope and fear are reactions that are anticipated by the person not only as an immediate consequence but also on a long-term perspective. Consumers may for example decalcify their kettle regularly because they fear it will break down early if they do not perform this action. The wish to be socially accepted or avoid social rejection strongly influences people's everyday behaviour. Owning the latest version of a smartphone is often seen as a status symbol. Consequently, taking care of your smartphone in order to prolong its lifetime may not be seen as necessary for many consumers as it is replaced relatively early.

Ability consists of six parts: time, money, physical effort, brain cycles, social deviance, and non-routine. If a behaviour requires a lot of time, money or physical effort, the required ability is perceived as demanding. Brain cycles describe the cognitive effort, which is needed for a certain task. If a behaviour means that one has to break with socially accepted rules or norms, this is classified as social deviance, which makes it more difficult to conduct this behaviour. In general, people prefer things they do regularly, so non-routine behaviour is rated as less simple than everyday tasks. The assessment of ability depends on the individual: While some people may regard 20 Euros for a new shirt as too much money and therefore look for an alternative, such as repair an existing t-shirt, others would simply buy a new one. If a product care activity requires a demanding ability from the consumer, this can be regarded as a barrier towards product care.

Triggers are cues that provoke an immediate behaviour. To have the desired effect triggers should be given at the right time, that is when the behaviour can be initiated or executed. Three types of triggers exist: sparks (enhancing motivation) or facilitators (enhancing ability), signals (serving as a reminder). A spark increases the person's motivation, for example by evoking a feeling of hope or pleasure. An example is a sign near a public bicycle pump that tells you how much energy you can save by refilling your tyres. The sign thereby enhances your motivation right before the actual product care behaviour can take place. Second, facilitators enable a person to behave in a way that he/she wants to. This means that the person is motivated but is lacking the ability. For example, by enabling the user to place his/her order online in a fast and convenient way, such as a "one-click button", his/her ability is enhanced. Third, signals are triggers that work if a person is motivated and has the ability needed; they often serve only as a reminder. Examples are notifications from a garage that remind customers of regular check-ups of their cars or a light that indicates a repair on a coffee machine.

While the Fogg model has been developed to explain behaviour from a general perspective, previous research has shown that it can be applied to

product care [1]. Design can thus contribute to product care by stimulating consumers' motivation, by facilitating product care or by providing triggers.

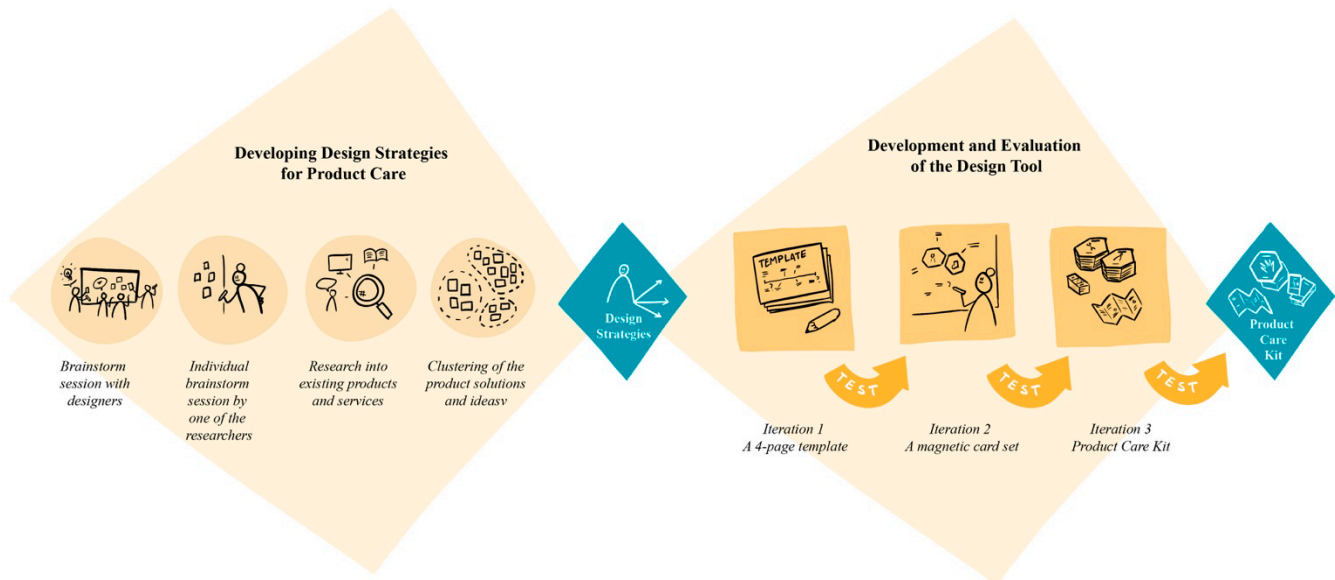
The second relevant source for our research are the seven design interventions to reduce the negative social and environmental impact of consumption suggested by Bhamra et al. [33]. These interventions include (1) eco-information, (2) eco-choice, (3) eco-feedback, (4) eco-spur, (5) eco-steer, (6) eco-technical intervention, and (7) clever design. These interventions vary in the level of control they offer the consumer: Eco-information refers to design-oriented education. For product care, this could mean that the consumer is made aware of his/her lack of product care and the expected consequences thereof. This purely informational approach offers the largest amount of control or freedom to the consumer because the initiative for product care lies with the consumer. The least control is given through clever design, which describes a design that would automatically lead to product care, without the consumer being aware of it.

Neither Fogg's model and Bhamra's design intervention strategies, nor other design literature or toolkits that we are aware of provide design strategies that target consumers' care behaviour. We therefore developed design strategies that focus on the consumer's role in product care. Fogg's behaviour model [39] was used as a theoretical model for understanding the different underlying factors that influence behaviour (i.e., motivation, ability, triggers) and that can be influenced by design. The design intervention strategies by Bhamra et al. [33] served as an inspiration for our design strategies, because they are addressing behaviour change for sustainability, albeit without focusing on a specific sustainable behaviour.

## **METHOD**

The following section describes the methods we used to develop first the design strategies for product care, and then to transfer these strategies into a toolkit for designers (see Figure 1).





**Figure 1.** Overview of the development of the design strategies and the Product Care Kit.

### Developing Design Strategies for Product Care

As a first step, we aimed to collect a large number of existing products, services or product/service concepts that stimulate consumers to perform product care activities in one way or another. This would allow us to look for patterns or overarching themes, which would form the basis of the development of concrete design strategies. Because existing design strategies in the literature have focused on the facilitation of repair and maintenance, this research looks beyond these strategies. It looks for design inspiration in practice, for existing and conceptual products/services that encourage consumers to take care of their products.

A multi-method approach was chosen because we wanted to combine existing knowledge and strategies with new ideas and concepts. We aimed for design strategies and examples that have a theoretical background, for example, from research on repair and maintenance, and are relevant for design practice. During all process steps, the focus was on existing and conceptual products/services that stimulated product care among consumers. Three different methods were used: (1) a brainstorm workshop with designers, (2) an individual ideation session by a designer (second author), and (3) desk research. Method 1 was a workshop setting with a group of 5 designers that lasted around 2.5 h, which enabled us to get a view on the various approaches that designers can take on fostering product care through design. During the individual ideation session, the designer thought through ideas in more detail, related them to prior knowledge from existing literature, and explored specific combinations explicitly, for example by using a Forced Fit Method that considered factors, such as the human senses systematically. Desk research was performed in order to identify existing products and services that stimulate product care behavior in today's markets. Combining these three methods ensured that novel ideas were combined with existing



knowledge, and that ideas from practice as well as from scientific research were considered.

To effectively elucidate product care as a concept to the participants of our workshops, we explained seven different types of product care activities that consumers can execute based on prior research [1]: repair, preventive measures, product revival, creating something new/different, small care, instructed & mindful handling, and routine acts. Table 1 shows the different product care activities that were presented to the participants of the workshop. They received a written definition and an illustrated example. We believe that there may be some overlap between the different types of product care activities. For example, product revival and repair can contain similar activities for certain products: Replacing parts of a bicycle because it is not pleasant to cycle could be seen as either repair, because the product does not function properly anymore, but also as product revival because product care is executed to make it perform better. However, the main aim was to have a comprehensive overview of different types of care activities, due to which overlap between the different product care activities was not seen as an issue.

**Table 1.** Product care activities (based on [1]).


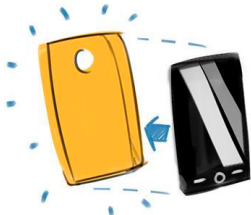

Product care activity	Description	Illustration
Repair	<p>Repair consists of activities that will make the product function properly again. This can be the repair or the replacement of broken parts. The product or a part of the product is usually broken. This prevents the product from performing its primary function, performing a specific function or performing satisfactorily.</p> <p><i>Example: Changing the tire of a bike when it is punctured, or glueing the ear back on a coffee mug after it fell and broke.</i></p>	
Preventive measures	<p>Preventive measures that are taken to make sure a product breaks or deteriorates slower than usual. These measures often consist of external products or services that equip or protect the product against its environment.</p> <p><i>Example: Putting a phone case on a phone or spraying hiking boots with a water-resistant spray.</i></p>	
Product revival	<p>Product revival consists of activities that revive a product to a certain standard. This means that product care is performed in order to make the product work more fluently/better/faster. It can also imply that after these care activities the product obtains a more appealing appearance.</p> <p><i>Example: Cleaning and greasing the chains of a lawnmower, or sanding and varnishing a scratched-up table.</i></p>	

Table 1. Cont.

Product care activity	Description	Illustration
Creating something new/different	<p>Creating something new/different consists of activities that result in an end product that is new or different from the original product. It can consist of one or more products, where the existing products are remodelled/rebuilt/reformed so it feels like a new, different or personalized product to the user. This means that instead of replacing or throwing out the old product, the old product or its materials are used to make a new/different product.</p> <p><i>Example: Painting an old IKEA kitchen cabinet and adding legs to create a nightstand, or using the fabric of an old pair of jeans to make a handbag.</i></p>	
Small care	<p>Small care consists of activities that are done to freshen up the product, to maintain the quality of its aesthetics and/or its performance. These are activities that are usually low in effort and/or time.</p> <p><i>Example: Polishing silver earrings, or pumping the tires of a bike when they feel a little soft.</i></p>	
Instructed & mindful handling	<p>Instructed &amp; mindful handling implies that the user actively aims to treat and take care of the product in a good way. The product is kept in a good state because the user consciously refrains from behaviours or actions that negatively influence the state/lifetime of the product and only perform acceptable behaviours or actions.</p> <p><i>Example: Not using metal cutlery in pans to prevent the non-stick coating from getting damaged, or rolling up the charger for a laptop carefully before storing it in a bag.</i></p>	
Routine acts	<p>Routine acts consists of activities that the user performs unconsciously. The consumer learned to do this behaviour and has never thought about doing it differently. These habits are often short or small activities that are done regularly and have become part of people's routine.</p> <p><i>Example: Cleaning cast iron pans by hand instead of putting it in the dishwasher because this is how your caregivers did it, or brushing of the mud of a pair of rugby shoes after each rugby training because everyone else does so after leaving the training.</i></p>	

### Workshop with designers

The first brainstorm session was conducted with four design students who had a bachelor in design and one UX designer with a master in design. None of the participants had experience with designing for product care specifically or were consciously aware of design strategies for product

care. In the week before the brainstorm session, participants were sensitized to the topic of product care. They received a short written introduction including the definition of product care and the seven different types of product care activities, together with their descriptions (see Table 1). Participants were also asked to think of one product that they take care of and one product that they do not take care of and think through why this is the case.

At the start of the brainstorm session, which lasted approximately 2.5 hours, participants were briefed about the purpose of the research, and about the goal of the session. A short discussion was held about the homework assignment. Here, the group talked about the products that they repaired or maintained and why they believed they were successful in this. Next, they discussed why they failed to maintain or repair their second product. By discussing their own experiences and motivations to perform product care, they were sensitized to consider the consumer who needs to be persuaded or motivated to perform care activities. Participants were then asked to write down and tell their initial ideas and thoughts about product care on sticky notes to encourage the flow of writing and talking about their thoughts and ideas with the group. Three rounds of brainstorming took place. In the first round, participants were asked to write down product solutions for each type of product care activity, that they could come up with. In the second round, participants were asked to write down product/service solutions for the products that the participants did not maintain or repair. In the third round, participants were asked to write down product/service solutions for different product categories (as used in [1]) in order to ensure strategies for a broad range of products. These categories were: household appliances and tools, consumer electronics and communication devices, means of transport, furniture and interior design items, clothes, shoes and fashion items, sports equipment, and accessories for hobbies and leisure. To ensure that that the products differed from the ones chosen by the participants for the second round, the researcher prepared a set of possible products beforehand. All ideas and solutions during the session were written down on sticky notes and stuck to the wall where everyone could see them. Participants were encouraged to write down their solutions themselves or say the idea out loud, so it would evoke discussion or inspiration within the group. The brainstorm session resulted in 140 product/service solutions and ideas.

#### *Individual brainstorm session by one of the researchers*

After the brainstorm session with designers, an individual brainstorm session was held. During this individual brainstorm session the second author of this paper, who holds a BSc in industrial design and was, at the time, finalizing her Master degree in Design for Interaction, ideated additional product/service solutions. The aim of this step was to find as many solutions as possible. The brainstorm was executed by brainstorming/drawing through associating [40].

To ensure variety in the type of solutions that would be created during this step, the researcher switched her focus continuously between the different types of product care activities and the different product categories. She also used the human senses (sight, smell, touch, hearing, taste) as an inspirational trigger to widen the solution space even further. By using a human sense as a trigger, different ways of approaching the consumer were ensured. In the case of slow ideation, a Forced Fit method [41] was used. During this Forced Fit method, the designer randomly picked one of each: one of the six product categories, one of the seven product care activities and one of the five human senses. This way, she forced herself to consider solutions that she would otherwise not have thought of. If one idea triggered the next one without picking a new set of triggers, that idea was also documented. All product solutions consisted of a simple drawing with an explanation of how it would work.

The brainstorm session resulted in 63 solutions for product care. These product/service solutions are additional solutions, which target product care in more unexpected angles due to the Forced Fit method and therefore help cover a larger field of product care solutions and minimize the chances of uncharted strategies.

#### *Research into existing products and services*

An extensive inquiry was conducted via searching on the internet, asking colleagues and acquaintances and by looking into prior experiences [42]. By asking colleagues and acquaintances to share their care experiences, we received more insights in what motivates and pushes consumers to perform product care. The aim of the search was to look for existing products and services that stimulate product care behaviour. For example, the municipality of Rotterdam placed bike repair poles near bicycle paths providing cyclists with the right tools to pump or repair their bikes. There are also product and services that can lead to enhanced product care behaviour due to a clever design feature. An example is the Doppo bottle ([www.dopper.com](http://www.dopper.com)), which can be screwed open to transform the bottle into a cup. Additionally, this makes it possible for the consumer to properly clean the bottle on the inside and reuse it.

This desk research led to another 76 solutions, which were all documented in the form of a picture of the product/service and a short description of how it may promote product care behaviour.

#### *Clustering of the product solutions and ideas*

The collection of products and product concepts resulted in 279 solutions that stimulate product care through their design. The ideas and concepts were first clustered individually by two researchers. The aim was to identify different strategies and sub-strategies that foster product care among consumers through means of design. To ensure a profound understanding of the solutions as well as of the aim of the strategies, these two researchers both had a background in design, one in industrial design

engineering and the other in interaction design. During this clustering process, they looked at similarities between the different solutions with respect to the way in which a product or service stimulated or evoked product care among consumers, e.g., by enhancing their motivation or by serving as a trigger. Afterwards, both researchers discussed the created clusters in detail with each other. As their clustering mainly differed in the naming of the strategies, consensus could be found within one session of around 45 min.

### **Development and Evaluation of the Product Care Toolkit**

In the first part of our research, eight design strategies and 24 sub-strategies to stimulate product care were uncovered and presented in written text. Even though these design strategies can help designers in providing inspiring, new ways to consider care activities in the design of products and services, the textual presentation form (see Table 2) may not provide an optimal fit with the design audience and the purpose of the strategies. Many designers are used to working visually, work with interactive or physical design tools and/or are in need of quick information. Furthermore, a fun, visual and easy to use design tool is more likely to inspire and enthuse people about product care than a piece of text can. This means that the design tool should explain the strategies in a concise and a visually pleasing way.

We looked for inspiration in existing tools and methods of different formats. The tool is intended to be usable in ideation with multiple people and creative sessions, because in (design) companies creative sessions with teams or multiple parties are often used to reach a solution for a customer's or company's problem, to create a vision for the company or to create a new product/service.

The textual design strategies (see Table 2) were implemented in a toolkit. The aim of this toolkit is to teach designers about product care and provide inspiration on how to design for it. In order to confirm that designers are able to use the toolkit for the standard design cycle [43,44], the Product Care Kit was tested multiple times with designers.

#### *Iteration 1—A 4-page template*

A preliminary version of the toolkit (see Figure 2) consisted of:

- *Design strategy cards.* Eight cards describing the different design strategies.
- *Example cards.* Around 30 smaller cards with examples of (existing) product/service solutions matching the different design strategies.
- *A 4-page template.* A writeable template to assist the designer(s) in their design process. It posed questions that would help the designer(s) to elaborate on the context and product that they are designing for and explained the different types of product care activities in the process.



This version was printed out and evaluated by the research team and four design students. The design students were asked to explain how they thought the template was to be used, how they would prefer to use it, and in what way they generally use design tools in their design projects.

(A)



(B)



**Figure 2.** The first iteration consisted of (A) a 4-page template and (B) yellow cards with an explanation of the design strategies and white example cards with product/service solutions.

The main result of this first iteration was that the research team obtained more insight into how designers and design students would apply this new design tools in practice. The following conclusions affected the next iteration greatly:

- The process of using the template was too linear for the participants. Because a design process is almost never linear and designers tend to go back and forth in their process, the tool should be flexible to adapt to that.
- The information that designers needed to read to be able to use the tool was too extensive.
- Questions were used to encourage designers to think about the different aspects of product care and the context that they were designing for. However, participants often did not take the time to read all of these questions due to the linear format.
- The tool was conceptualized for use by a single or two designers but its format should be usable by a group of designers.
- It was not clear for participants if there was a link between the different types of product care activities and the design strategies. They wanted to know if specific strategies fit specific types of product care activities.

This resulted in the following changes being made in iteration 2:

- The toolkit consists mainly of a card set. As a consequence, no strict rules or processes need to be followed, and not all cards have to be used each time. To help users with starting the toolkit usage, a concise



instruction booklet was added to explain each type of card and to explain how the card set can be used.

- In addition to the design strategy cards and the product/service example cards, extra cards were added to the toolkit to define the context that is being designed for. These extra cards were: product care activities cards (with an explanation and questions related to the seven product care activities in order to educate designers about different care activities); persona cards (with questions to define the target group); and product cards (with questions to define the product and its context). The cards and its questions are meant as triggers for providing inspiration, starting discussions and trying out different angles for the design solution.
- The card set was made to be magnetic to use it on whiteboards with a design team.
- On the product care activities cards, a note was added with which design strategy they have often been paired with.

#### *Iteration 2—A magnetic card set*

The second iteration was a magnetic card set (see Figure 3), consisting of:

- *Product care activity cards.* Seven cards describing the different types of product care activities.
- *Design strategy cards.* Eight cards describing the different design strategies and their sub-strategies.
- *Product cards.* Six cards that give five examples of products to focus on, and a card that shows a question mark, for other products.
- *Persona cards.* Eight cards that show different types of users to focus on.
- *Example cards.* A large amount of smaller cards with examples of (existing) product/service solutions matching the different design strategies.
- *A leaflet.* A textual explanation on the content of the magnetic card set.

Six participants (four design students with a bachelor in design and two UX designers) evaluated this iteration of the toolkit. None of the participants had experience with designing for product care or were consciously aware of design strategies for product care. In the week before using the toolkit prototype, the participants received a short, written introduction including the definition of product care and the seven different type of product care activities with their illustrations (see Table 1).

For the evaluation sessions, participants were placed in pairs and asked to use the toolkit to create one or more product/service solutions that stimulated people to perform product care for a product. Participants received the card set and the instruction leaflet and did not receive extra information on how to use the card set. The whole session lasted one hour

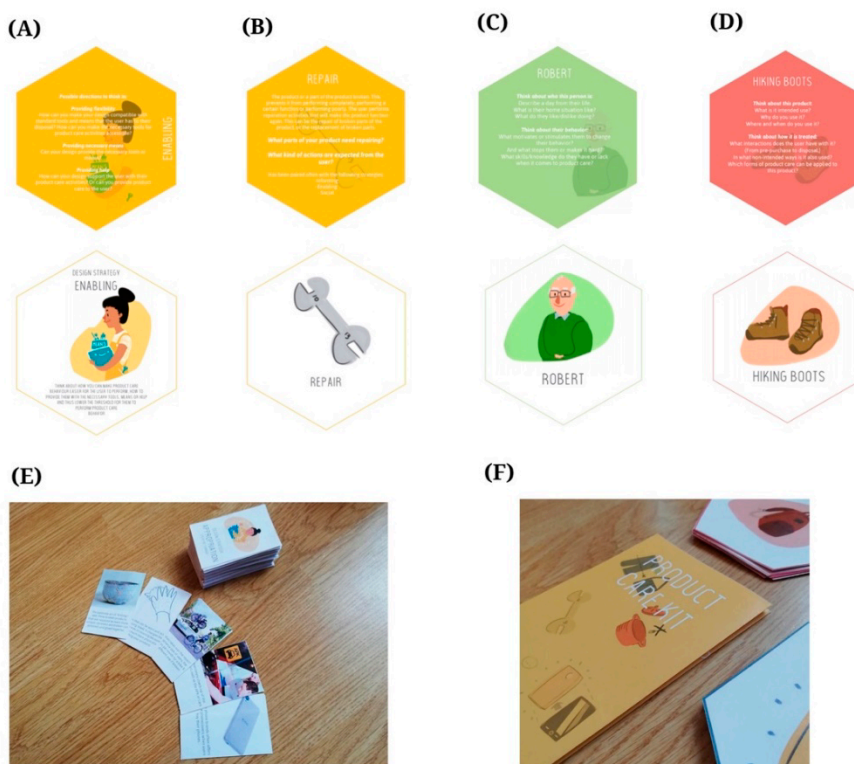
per pair, including an evaluation session at the end. During the evaluation session, participants thought out loud and explained how they thought the card set was to be used and how they would prefer to use it.

The main insights during this evaluation were:

- The toolkit was seen as practical and inspirational; all participants agreed that the toolkit could help them in designing new solutions for product care.
- Outcomes from the toolkit range from conceptual product ideas, to a visual map of the context and deep discussions that generated new insights and knowledge about product care, with the participants.
- It was difficult to see which cards belonged to which category, because the cards had similar colours.
- The participants felt that the texts on the leaflet and the cards was too lengthy and would not read through all of it.

This led to the following changes being made for the final version of the toolkit:

- Colour coding the border and backside of the cards to indicate the different types of cards.
- Rewriting the text on the cards to make it more concise and clearer.
- Rewriting the text on the leaflet and adding pictures to make it more concise and clearer.



**Figure 3.** The second iteration magnetic card set consisted of (A) design strategy cards, (B) product care activity cards, (C) persona cards, (D) product cards, (E) example cards and (F) an information leaflet.

### Evaluation

Ten toolkits were produced and used for a workshop at the PLATE (Product Lifetimes And The Environment) 2019 conference in Berlin, Germany. We did not only want to test the toolkit in practice but also aimed to learn more about its relevance for design practice. After a short presentation of the background and the theory behind the toolkit, 25 participants worked with the toolkit in groups of five people (Figure 4). We asked them to select a product based on their own care experiences or from examples provided in the toolkit and to create ideas on how to stimulate product care for this product. After approximately 45 minutes, the groups presented their concepts. At the end of the workshop, we handed out a short paper-based questionnaire asking them for general feedback, how the toolkit influenced their design process and possible fields of future application for the toolkit through open questions.



**Figure 4.** Testing of the toolkit during the PLATE workshop.

## FINDINGS

### Design Strategies for Product Care

The clustering resulted in eight design strategies to stimulate product care, and 24 sub-strategies (see Table 2). In the following section, we explain the strategies and compare them to the two models for behaviour change described in the introduction of this paper as well as to previous research findings as a first step of validation. We will also explain their relevance with respect to recent civil and political initiatives.

**Table 2.** (Sub-) Design strategies to stimulate product care.

Design strategy	Sub-strategies	Explanations & examples
informing	static information	The consumer is informed about product care through static manuals or tutorials, e.g., written paper manuals.
	interactive information	The consumer is informed about product care through interactive platforms, e.g., interactive websites, workshops or online tutorials.
	physical information	The consumer receives information or clues about product care through affordances and through the design, e.g., material.

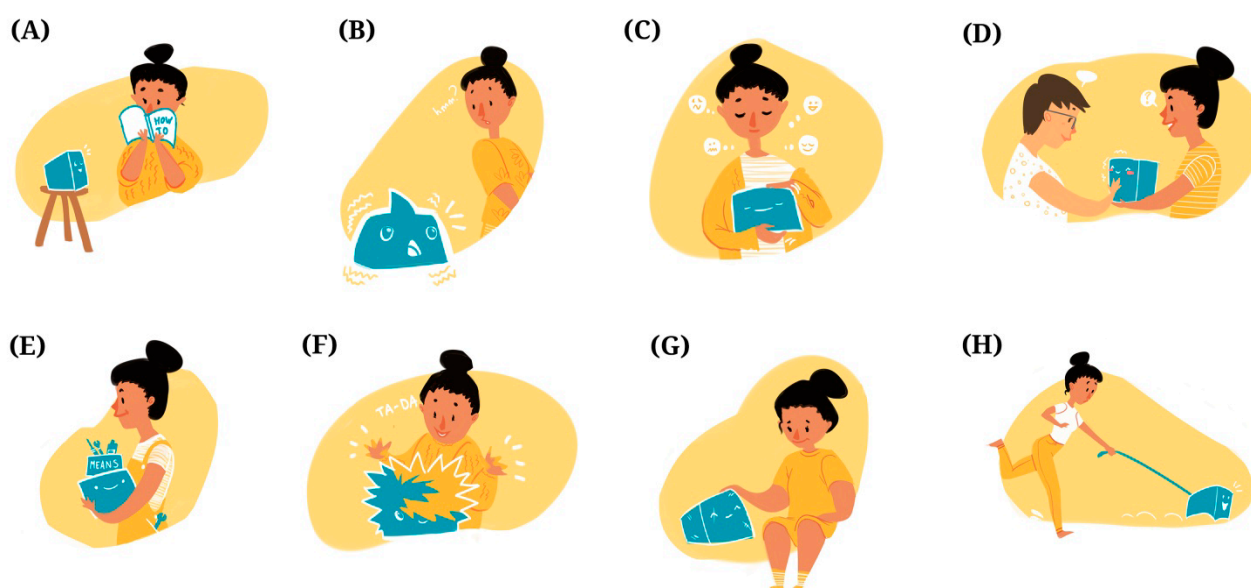
**Table 2. Cont.**

Design strategy	Sub-strategies	Explanations & examples
awareness	push messages	The consumer's awareness about the need for product care is increased via specific messages, e.g., notifications on the smartphone or notification lights in the car dashboard.
	product changes in appearance	The consumer's awareness about the need for product care is increased via changes in the product appearance, e.g., seeing the greyness of a wooden table.
	product changes in functionality or performance	The consumer's awareness about the need for product care is increased via changes in the product's behaviour, e.g., a bike chain that makes a rattling noise.
antecedents & consequences	anticipating effects	The product creates associations between negative effects and non-care or positive effects and product care, making the user think of the consequences of non-care and product care, e.g., a warning message on washing labels of a wool sweater or an app where you can post about your product care activities and you can receive rewards or 'likes' from other consumers.
	after-effects	The consumer can see the effects of product care, because it is made (extra) apparent through the product, e.g., a table that looks shiny after varnishing it.
social connections	social connections as facilitators for product care	Product care activities are supported by other consumers or people, transforming product care into a social activity e.g., a DIY repair shop where consumers get help from other consumers or an expert.
	social connections as a result of product care	By making product care result in social contact with others, product care can be seen as the step to having more social interactions with other consumers or people, e.g., a club of old-timer owners who share their tips on product care for their cars.
	shared ownership	The consumer shares and takes care of a product together with other consumers, which may lead to a sense of solidarity and shared responsibility, e.g., a car-sharing system.
enabling	providing flexibility	Through the compatibility with standard tools or easy accessibility of necessary tools, consumers receive more flexibility to be able to perform product care, e.g., the use of standardized screws.
	providing necessary means	The necessary tools and other product care means come together with the product and thereby provide the consumer with all the necessary means for product care, e.g., a spare button on the inside of a blouse.
	providing a service	Through product care services the consumer can let a service handle product care, e.g., a bike repair service.
appropriation	personalization	The product is adapted to the consumer's specific needs or preferences, thus heightening the chance of making the consumer feel more attached to this specific product, e.g., a custom-made bed frame or customized sneakers.
	ever-changeable products	By enabling the adaptation of the product during its time of usage the consumer can remodel the product according to the consumer's current needs, thus making the consumer steer away from the need for or desire of a new product, e.g., a modular phone that lets the user upgrade and adapt the same phone over and over (Phonebloks).
	creative change	By facilitating individual creative approaches, the consumer is likely to keep and upcycle the product and refrain from disposing of it, e.g., IKEA hackers guides or DIY activities.

**Table 2.** *Cont.*

Design strategy	Sub-strategies	Explanations & examples
reflecting	meaningful memories	An emotional bond is created between consumer and product through shared experiences or a specific meaning, making it difficult for a consumer to neglect or throw away the product, e.g., a lamp in which the height of your child can be recorded by scratching it as people would do on a doorpost or wall.
	showing traces	The product reflects previous interaction with the consumer, thus telling a story, e.g., a rug that reveals a different colour, texture or pattern after wear and where the gradual erosion heightens its attractiveness or kintsugi, the Japanese art of repairing broken ceramics with gold glue.
	experience of the product care activity	Product care is made into a pleasurable care activity, e.g., cleaning of a pair of shoes is made relaxing through the use of soft and precise cleaning tools or gamification.
control	product takes initiative	The consumer is pressured into performing product care because the product initiates (the first part of) a product care activity, e.g., a coffee machine that opens up to be cleaned.
	product handles product care itself	Through products that perform product care themselves, the consumer does not have to perform product care anymore, e.g., self-healing materials.
	unconscious takeover	Product care is made part of other routines in people's daily life, e.g., a tool rack that is incorporated into the keyrack near the front door, so the user will always see the tools when leaving or coming home.
	forcing product care	The consumer is forced to perform product care because the product stops working until it is being cared for, e.g., a coffee machine that refuses to work until it is decalcified.

To be able to communicate the design strategies within the research team, and also with others, one of the researchers made a visualization of each one of the strategies, see Figure 5.



**Figure 5.** A visual representation of the eight design strategies for Product Care. These are (A) Informing, (B) Awareness, (C) Antecedents & consequences, (D) Social connections, (E) Enabling, (F) Appropriation, (G) Reflecting and (H) Control.



*Informing* refers to providing consumers with different kinds of information. Educating consumers to be environmentally friendly has long-lasting effects on sustainable consumer behaviour and lies within the responsibility of manufacturers [45]. Besides well-known means, such as written manuals and instructions, this strategy can be implemented through interactive means, such as online tutorials, workshops for consumers etc., that are offered as a service by the producer. In addition, the product itself can include affordances for product care through its design, e.g., via the material or the shape. An example of this sub-strategy are Miele dryers that indicate the possibility to remove and clean the fluff filter by an orange dial. The overall aim of this strategy is to heighten consumers' knowledge of product care to facilitate care activities. *Informing* enhances consumers' knowledge about product care and therefore their perceived ability according to Fogg's behaviour model [39]. This strategy can also help to provide information about how a product works and how it can be taken care of. With this strategy, control stays with the consumer and not the product, because the consumer still has to take initiative. Hence, it is related to the eco-information strategy suggested by Bhamra et al. [33]. As information about product care takes the consumer's interaction and his/her possibilities to influence the product's lifetime into account, the eco-feedback strategy (ibid.) might also apply. *Informing* is in accordance with previous research that suggests that it already helps to provide the consumer with useful repair [28] or care information [7,46] to foster product care. One popular initiative in this field is iFixit.com. It is based on the belief that "people should be able to use their stuff how they want to, for as long as they possibly can" ([47], p. 124) and offers more than 10,000 free repair guides online.

*Awareness* refers to reminding the consumer of the fact that he/she should take care of the product. It is especially relevant for products that consumers often forget to take care of. Simple reminders, such as an alarm on the smartphone or an e-mail by the service provider, can already enhance consumers' awareness in a specific situation. Examples for this strategy are dishwashers that signal the need of rinse aid or car garages that remind consumers of the next car service. Furthermore, the product's appearance may change to encourage consumers to take care, such as a surface that looks unappealing when it is not being cared for, such as leather shoes that look unaesthetic if they are not cleaned and waxed regularly. Also, a decrease in the product's functionality can raise awareness. This is especially relevant for technical products, such as a bicycle that is harder to pedal if the chain is not oiled properly. *Awareness* concerns small hints and cues that prompt an immediate reaction. By making the consumer aware of the need for product care, they serve as triggers, as defined by Fogg in his behaviour model [39]. If motivation and perceived ability are present at this time, triggers should thus stimulate care activities. This strategy is related to eco-feedback [33], which refers to



tangible aural, visual, or tactile cues that remind the consumer of his current behaviour.

*Antecedents & consequences* refers to communicating the possible effects of product care—and also of non-care—to the consumer to encourage him/her to execute care activities. For example, if the consumer learns about the advantages of a well-maintained bicycle, such as less effort while cycling, it can motivate him/her to conduct these care activities. When a product is especially shiny or well working after product care, it might motivate the consumer for future care activities. *Antecedents & Consequences* is strongly related to motivational factors of product care, which either have to be present before the care activity takes place or which are expected to occur after the care activity. This strategy is therefore strongly similar to Fogg's [39] dimensions of motivation, such as pleasure/pain, hope/fear and social acceptance/rejection. The eco-spur design strategy [33] is based on rewards and punishment for sustainable behaviour and can thus also be linked to this strategy.

*Social connections* refers to the facilitation of product care through the consumer's social interactions. Specific communities can support consumers in their care activities, such as repair cafés or shared private garages to work on cars. Conducting care activities in these settings on the one hand facilitates repair and maintenance because equipment, as well as knowledge and skills, can be shared with other people. In addition, shared garages offer enough space for care activities, which is often not given at home. Another aspect is that social connections can be seen as the result of product care activities when interactions among people are created through product care. The motivation for product care is enhanced through social interactions, and it is facilitated by offering access to tools and space. As such, it is related to motivation as well as ability in the model by Fogg [39]. Another sub-strategy is shared ownership, which means that a product is used by several consumers. This is often the case in shared apartments, and also in offices or other workplaces. In these settings, products are often not owned by a single person. Because people know that the same product is used by their housemates or colleagues, they can feel more obligated to take care of it. One reason for this behaviour is that they fear social rejection (as described in Fogg's model as a driver for motivation) if they handle the product carelessly. The effectiveness of this sub-strategy may be limited in anonymous setting where others would not know who is responsible for a lack of product care. Social connections as a strategy to stimulate product care are barely part of existing models and strategies in the field of sustainable design. However, this strategy is well established in practice: The rise of repair cafés, where people meet and repair their products together demonstrates the relevance of the social environment for repair [48,49].

*Enabling* refers to facilitating consumers to perform product care activities in a more practical way by offering the right tools together with the product, ideally already at purchase. As an example, sewing machines are often delivered together with tools to open the machine, with a small bottle of motor oil as well as with brushes to remove dust. This makes it convenient for consumers to take care of them. Another part of this strategy is to enhance the flexibility for repair and maintenance by designing the product in a way that standard tools and materials that are available in most households can be used. This strategy is not only related to the availability of care equipment or spare parts, but also to the corresponding financial burdens: As prior research [19,20] has shown that the product's initial price often determines if a product is being taken care of, product care should be possible at a reasonable price. A negative example for this strategy are products by Apple that require special screwdrivers to open them. The establishment of a network of service providers that help consumers to repair and maintain the product is another example of the design strategy *Enabling*. *Enabling* is related to the ability dimension of Fogg's behaviour model, as it facilitates product care by different means. The strategy is related to circular design strategies, such as Design for Standardization & Compatibility and Design for Ease and Repair [50] as well as to strategies to postpone replacement, such as Design for Reparability as proposed by [24]. Making product care easier provides the consumer with a sustainable option for his/her consumption and can be seen as part of the eco-choice strategy by Bhamra et al. [33].

*Appropriation* refers to the adaptation and/or personalization of a product through the consumer. This can be achieved by modular, ever-changeable products that allow the replacement of certain parts when an upgrade is desired. *Appropriation* also describes a product design that encourages the consumer to change the product in a creative way, such as upcycling and do-it-yourself activities. As a consequence of these creative activities, the consumer can feel more attached to this product and is more likely to take care of it. By creating a pleasurable experience of the product, this strategy is related to Fogg's concept of motivation [39]. *Appropriation* consists of the three sub-strategies personalization, ever-changeable products, and creative change. Personalization has been identified as a determinant of product attachment by Mugge et al. [51], which in turn can foster product care [17]. Investing time in a product and thereby increasing the personal value of this product can be seen as part of the Slow Design approach [52,53]. The sub-strategy of ever-changeable products is related to Design for Adaptability & Upgradeability [50] that focuses on the possibility to adjust products to the consumer's changing needs. The final sub-strategy, creative change, matches the upcycling approach [54,55], where products are improved by means of renovating, or by adding or changing components.

*Reflecting* refers to meaningful memories and traces that are created through the interaction of the consumer with the product by creating a special meaning for the consumer, the motivation to take care of this product increases. An example is a skateboard with scratches as a result of its usage. The consumer may want to preserve these reminders of past adventures with the skateboard, and will consequently take better care of it. This valuable memory can be created through the interaction with the product or the care activity itself. For example, painting a wooden piece of furniture can generate a unique value for the consumer, because he/she remembers that activity in a positive way. Another corresponding aspect of reflecting is the gamification approach: Gamification connects the care activity with fun and pride, which can stimulate consumers to perform product care activities in the future. *Reflecting* can be linked to many existing design strategies and models. In general, it addresses the motivation to take care of the product, because it creates relevant and positive emotions as mentioned by Fogg [39]. The relevance of meaningful memories is part of the Design for Attachment & Trust principle [50,56] and Emotionally Durable Design [57]. It can be found within the Slow Design approach that suggests that the traces of the relation between consumer and product should be made visible [53]. This strategy also concerns the experience of the product care activity itself, Pohlmeier [58] mentions creating a design that sustains and optimizes positive emotions from a positive experience in her strategy *Design for Savoring*. It does not necessarily focus on creating pleasurable experiences, but more on the appreciation of experiences.

*Control* refers to how much control over the product care behaviour is given to the consumer. Control can be applied with different intensities: One option are products that start the initiative for product care themselves. An example is a coffee machine that not only informs the consumer on the display when maintenance is needed but even opens the parts that should be cleaned. Taking over the initiative or starting the product care process can be seen as a trigger that enhances the consumer's motivation as well as his/her ability to conduct the care activity immediately. For other cases, the product encourages the consumer to take care of it regularly, so it can be seen as an unconscious take-over of control, as product care becomes a habit. An example is a reflex camera that keeps on reminding the user to put the cover back on the lens when turning the camera off. After some time, this action becomes a habit and the lens is always protected. Self-healing materials can be seen as part of this strategy because they contribute to the product being repaired without any intervention or action conducted by the consumer. The products, therefore, take care of themselves as a result of their (novel) materials. The application of self-healing materials in product design can enhance physical durability and reliability, and thereby reduce cost and risk of future repair [59]. The most controlling version of this strategy is a product that refuses to work if it is not being cared for. For example, a

kettle can stop boiling water until it is decalcified. Control can be linked to Fogg's concept of triggers because it prompts a certain behaviour more or less strongly. *Control* is closely related to some of the design strategies proposed by Bhamra et al. [33]. Similar to our sub-strategies, their strategies eco-steer and eco-technical intervention also represent different levels of control being taken over by the product, ranging from integrating constraints and affordances into the product's design to technology that controls consumer behaviour. Clever design, their strategy with the most control for the product and the least control for the consumer, decreases consumer's behaviour without even raising awareness. This equals our sub-strategy of unconscious takeover, where product care eventually becomes a habit in daily life.

### **Product Care Kit and Its Evaluation**

The final version of the toolkit (see Figure 6) is designed as a card set and helps designers to understand the many aspects that are relevant when designing for product care. The card set consists of:

- *Product care activity cards*. Seven cards describing about the different types of product care activities. The backside poses questions related to the desired product care behaviour.
- *Design strategy cards*. Eight cards describing and posing questions about the different design strategies and their sub-strategies. The backside poses questions related to the design strategy.
- *Product cards*. Six cards that give five examples of products to focus on, and one card that shows a question mark, for other products. On the backside, questions are posed that relate to the product and context, for the designer to ask him/herself.
- *Persona cards*. Eight cards that show different types of potential users that one can focus on. The backside poses questions related to the user, for the designer to ask him/herself.
- *Example cards*. Forty-eight smaller cards with examples of (existing) product/service solutions matching the different design strategies.

For easy recognition, each card has an illustration corresponding with the presented category and topic. Ideally, the cards are magnetic, which grants designers the opportunity to use them on whiteboards. The cards present questions that trigger the designer to think about how to realize product care with their design. The different types of cards pose different types of questions, related to the category of the card. For example, the persona card invites the designer to define their target group with amongst others, questions such as: '*What is their home situation like?*' and '*What skills/knowledge do they have or lack when it comes to product care?*' The persona on the card has an illustration of a specific type of user (e.g., young boy, elderly man) that can also serve as inspiration.

All design strategy cards present questions related to that strategy. For example, the card for the design strategy Control, asks questions such as:

“How can your design take the first step of product care?” and “How would your design force the user to perform product care?” The card for the design strategy Appropriation poses other questions, related to the specifics of that strategy. For example: “How can your design provide the user with the possibility to alter their product before/after purchase?” and “How can your design adjust themselves to the changing needs of the user?”

The questions on the cards help the designer to formulate a clearer image of the context and user that they are designing for. As discussed in the literature, it can be difficult to persuade consumers to perform product care (see [1]). These questions help the designer to gain insight in the user and their behaviour, in the desired product care behaviour and the different angles the design strategies (and sub-design strategies) pose. When taking these different aspects into consideration, designers can better target and design for the desired behaviour they want the user to perform.

The toolkit can be used by an individual designer or a group of designers within the ideation phase in order to stimulate ideas for product care-friendly products and services, as well as during discussions in a team setting.



**Figure 6.** The final version of the Product Care Kit. (A) Examples of the persona cards (green), product care activity cards (blue), design strategy cards (yellow) and product cards (red). Portraying the front. (B) Example of the persona cards (green), product care activity cards (blue), design strategy cards (yellow) and product cards (red). Portraying the back. (C) A stack of example cards showing inspiring product/service solutions that fit with the different design strategies (presented on other side). (D) A booklet with instructions for the card set.



### *Findings from the evaluation at the conference workshop*

All five groups were able to use the toolkit after a short amount of time to develop ideas to stimulate product care. We received 21 feedback sheets from 7 participants from industry and 14 from research and education, all in the field of design, sustainability and consumer behaviour. All participants indicated that the toolkit helped them create new ideas, think outside the box and provided them with new insights into product care. As an example, they mentioned that they would have focused only on repair before, because they never thought about other aspects of product care, such as careful handling, or sometimes even maintenance. The toolkit facilitated group discussions and communication and structured their design processes. When asked about possible fields of application, many participants suggested design education, as well as design in practice. Some participants also mentioned other application areas, such as using the toolkit to discuss with other stakeholders about Eco-Design. Ideas for improvement concerned better instructions, especially for the first phase of the design process, and a more elaborate description of the persona cards.

### **IMPLICATIONS**

Product care can extend the lifetimes of products, because they remain in a usable state for a longer period of time. Consumers are in general motivated to take care of their products, but often fail to include these activities into their daily life. Design has the potential to change consumers' behaviour, but design strategies for product care are currently still missing.

We identified existing product/service solutions that stimulate product care among consumers and added further ideas that we developed together with designers and within the research team. This led to 279 solutions and ideas. One important step was the clustering of these solutions and ideas, because it enabled us to identify design strategies that represent directions to consider during the design process. These design strategies are: informing, awareness, antecedents & consequences, social connections, enabling, appropriation, reflecting, control. The design strategies were split into 24 sub-strategies that represent different aspects of how the strategy can be used for product and service design, and therefore, facilitate the implementation of the superordinate strategies. The design strategies as well as the sub-strategies were transferred into the Product Care Kit. The toolkit is a cardset that can be used during the ideation phase of the product/service development processes. Besides the strategies, the toolkit includes cards that show examples of existing solutions for product care, cards that show different product care activities and cards to consider the context of product care, i.e., persona cards and product cards. The toolkit has been developed in an iterative process, and the final version was tested during a conference workshop.



Our study contributes to the literature by providing specific design strategies to foster product care. Past research has either focused on behaviour change in general (see e.g., [39]), or on other more general ways of stimulating sustainable behaviour through design (see e.g., [33]). Our research builds on these theories as our strategies relate to the general constructs described, such as motivation, ability and triggers in Fogg's behaviour model [39] but also provides more detailed insights. Based on previous research [1] that suggests a value-action gap among consumers, we believe that more detailed insights and specialized design strategies are needed in order to assist designers to stimulate a specific sustainable behaviour, such as product care. In addition, we took the consumers' perspective explicitly into account: While previous research, such as the Design for Repair and Maintenance principle [8], has focused on the facilitation of repair and maintenance by changing the design of a product, we also considered consumers' motivation to take care of their products and the trigger(s) that pushes them to do so. Focusing on consumers' internal motivation appears to be a more promising approach compared to alternatives such as offering financial incentives for product care that would appeal to their external motivation. External incentives for sustainable behaviour, such as penalties or discounts, have been shown to encourage pro-environmental behaviour for the short term, but the intended behaviour often disappears as soon as the incentive is no longer offered (see e.g., [60]). If consumers take care of their products, these products remain in a usable and appealing state, which can serve as an internal source of motivation for product care. We therefore think that intrinsically motivating consumers and increasing the ability for product care as well as designing triggers is a more effective approach in the long-term, at least for products that are in ownership. However, for short-term rented products, such as e-scooters used by tourists, incentivizing a careful handling externally (e.g., via a penalty) may be a powerful approach.

The design strategies and their implementation in the Product Care Kit enable designers to design products and services that support product care among consumers. The results of our workshop evaluation are promising: Participants were able to use the toolkit during their ideation phase and recognized its additional potential for discussions or communication with stakeholders. According to Bocken et al., [61], a multi-stakeholder perspective is relevant for businesses that want to consider the social, environmental and economic dimensions of sustainability. While their value mapping tool aims to support the business perspective of sustainable thinking, our toolkit focuses on the designers' perspective.

Some design strategies are easy to connect with each other. For example, a booklet can provide information about product care (informing) and about the consequences of a lack of product care (antecedents & consequences). Appropriation and reflecting can be related to each other when a creative change of the product is an experience that is remembered by the consumer in a positive way. While these examples

can be seen as an overlap of design strategies, we argue that a clear distinction does not seem to be necessary to establish because the strategies should only serve as a source of inspiration and not a strict guideline in which only one strategy can be chosen. In fact, a combination of design strategies may be valuable to ascertain that consumers have the right level of motivation, ability and trigger(s) for executing product care.

## CONCLUSIONS

The aim of our study was to provide designers with means to foster product care through design. Our research contributes to the state of research by presenting eight design strategies (and 24 sub-strategies) to foster product care. In comparison to other design strategies for repair and maintenance [23–27], our strategies focus on the consumer perspective on product care. The strategies do not only facilitate product care through design but also aim to foster consumers' motivation and provide triggers. The practical value of our research lies in design strategies for product care that can actually be applied by designers and design students in practice. With our strategies and the Product Care Kit, practitioners can consider product care aspects for their products and services in order to create an impact of this research on sustainability. In the following paragraphs, we will summarize the applicability of our findings and present avenues for future research.

First, we want to highlight the relevance of product care for manufacturers. Current business models focus on profit maximization and subsequent short-termism and uncertainty avoidance [62]. These business models do not only create a negative environmental impact because consumers do not make optimal use of their potential lifetimes, but they also often have negative social-economic consequences, such as poor labour standards [63]. Financial gains with regard to product care are currently mostly achieved through the sales of spare parts, and sometimes through repair services. Manufacturers such as Patagonia and Fairphone already demonstrate that product and service design that support product care can work in practice: Patagonia is offering not only a repair service for its garments but also a cleaning service and asks its consumers to take over responsibility for their products (see <https://patagonia.com>). Fairphone produces smartphones that are made to last long and can be repaired easily (see <https://fairphone.com>). Products that can be easily repaired and maintained contribute to a higher brand loyalty and to an increased probability of future purchases by consumers [27,28], thereby highlighting the relevance of product care for industry. Future research should investigate the concerns that manufacturers may have when implementing such new sustainable business models. In addition, the wider implementation of circular business models, such as access-based product service systems, may further encourage product care in the future. In these access-based business models, consumers only use the product, but the ownership remains with the service provider.

Repair and maintenance are usually conducted by the service provider, so that the consumer does not have to worry about it.

Service providers also play an important role if ownership remains with consumers. Especially for complex products that require special equipment, such as smartphones or washing machines, consumers will often choose to contact a service provider. If more consumers decide to take care of their products, the repair and maintenance industry will be strengthened [64] and new jobs can be created. An increased interest in product care can stimulate an infrastructure that facilitates product care, with repair shops and repair cafés where consumers help each other to take care of their products, thereby encouraging new social interactions [48,49]. Product care has therefore the potential to bring about social and economic changes.

In addition, product care can lead to environmental benefits by extending products' lifetimes. Regular maintenance and a careful handling of products can postpone or reduce the need for repair and replacement [9,65–67]. Only in the case of a major technical breakthrough that leads to large improvements of energy efficiency in products, such as the LED technology for lights, existing products should be replaced from an environmental perspective. For most products, however, lifetime extension is the preferred strategy in terms of environmental benefits [50]. Product care does not only prevent failure, but also keeps the product on an optimal performance level and in an appealing state [1]. Future research could use big data analyses in order to assess the quantitative impact of product care on the extension of products' lifetimes and thereby on longevity for different products. These studies could collect data on product care activities, from the time of purchase until the disposal, for large numbers of products in different product categories. Analyses of this data could then quantify the effect of product care on the lifetime of products. Additionally, this data would allow for the determination of ideal intervals for different care activities. This knowledge could be used to remind consumers of necessary maintenance tasks, such as oiling of wooden furniture, in due time, as suggested by our design strategy awareness.

Only if the design strategies are actually used in design practice, they can contribute to more sustainable products and services and thereby support the shift towards a Circular Economy. As a consequence, we integrated designers into the development of the strategies and the toolkit as much as possible. While the overall feedback on our Product Care Kit was very positive, we strongly believe that future research is needed in order to understand how the toolkit can be used in daily design practice, such as in design agencies, because it has only been tested in a research setting. Testing the strategies in design practice would help us understand if certain design strategies are more difficult to implement, and how these challenges can be approached.

The effectiveness of our design strategies can be assessed in longitudinal studies, in which conventional products are compared with products that were designed based on our strategies. Through such studies, we could gain an understanding of the acceptance of the different strategies by consumers. Products that actually refuse to work if they are not cared for may be effective, but their acceptance may be lower than for other strategies, such as providing more information about product care, and in general vary over product categories. Another aspect that could be interesting for future research is the cultural context. The design strategies have been developed in Europe. It would be interesting to study product care in other cultures to investigate if cultures that have traditional repair practices, such as the Japanese kintsugi practice (see e.g., [68]), affect consumers' ability and motivation to take care of their products. Another difference may exist between different generations: Are consumers who grew up with limited access to materials and products, for example because of poverty or war, more prone to take care of their products? What role does the growing awareness of younger people, as for example can be observed in the Fridays for Future movement, play for product care? We would like to encourage future research to investigate product care across cultures and age groups in order to answer these questions.

As a next step, we encourage the usage of our toolkit in educational settings, such as for study projects of design programmes at universities. Integrating the toolkit in education would teach design students about the relevance of product care and how this aspect can be integrated in a product or service. We, therefore, provide a free download of the toolkit in order to encourage use in research and practice and contribute to its further development. We believe that when more designers, future designers and others that are interested, have the chance to be educated in designing for product care, we can design a world where consumers behave more sustainably and treat their products with care.

#### **DATA AVAILABILITY**

The dataset of the study is available from the authors upon reasonable request. The toolkit can be downloaded at [www.designforproduct.care](http://www.designforproduct.care).

#### **AUTHOR CONTRIBUTIONS**

Original draft preparation by LA and MT, review and editing by AP and RM.

#### **CONFLICTS OF INTEREST**

The authors declare that there is no conflict of interest.

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