Redefining Repair as a Value Co-Creation Process for Circular Economy: *Facilitated Do-It-Yourself Repair*

Serkan Bayraktaroğlu* and Elif İdemen

Istanbul University, Istanbul, Türkiye

Design for repair, maintenance, and upgrade has been increasingly recognized within industries striving to accelerate the transition to a circular economy. Although strategies to extend product lifespan require effective collaboration between companies and consumers, existing studies tend to focus on consumer attitudes towards do-it-yourself repair or professional repair services. Therefore, this study aimed to better understand potential user responses to Facilitated Do-It-Yourself Repair (FDR), a company-facilitated process oriented towards value co-creation, as conceptualized for this study. As a part of the exploratory qualitative research, semi-structured in-depth interviews and two desktop walkthrough sessions were conducted. These sessions were designed by adapting prominent features of similar business cases to hypothetical scenarios across four distinct product categories. Revealed codes were used to develop a conceptual model illustrating how user attitudes towards FDR may elicit a sense of empowerment and influence user perceptions toward companies that provide FDR resources. Findings based on product category-driven evaluation criteria indicate that companies providing such an experience are seen as reliable, customer-oriented, environmentally friendly, innovative, distinctive, and justified in charging higher prices for the goods they provide. Additionally, this study identified five distinct user roles that occur during repair and upgrade activities, elaborating on the *co-repairer* as a potential collaborator. Moreover, this paper highlights potential design and managerial implications identified during the study.

Keywords – Circular Economy, Design for Repair, Facilitated Do-It-Yourself Repair, User Roles, Value Co-creation.

Relevance to Design Practice – This study offers a conceptual model for progressive collaboration between companies and users in the context of the repair, maintenance, and upgrade of products to extend their lifespan. This model can help practitioners design an optimal experience by analyzing user perspectives and roles across four distinct product categories.

Introduction

With the rise of ecological, financial, and social problems on a global scale, sustainability has become a critical topic of discussion. Circular design thinking seeks to increase resource conservation, slow down resource loops, and adopt holistic system design approaches (Albæk et al., 2020; Bocken et al., 2016). To slow down resource loops, circular business models develop products and services that extend product lifespans by enabling product repair, upgrade, and reuse (Bakker et al., 2014; Kirchherr et al., 2017; McQueen et al., 2023).

Repairability assessment tools such as the Repair Score System, EN 45554, and the French Repair Index have been recently introduced to evaluate specific product categories (Dangal et al., 2022). Right-to-Repair (RTR) initiatives call on manufacturers to produce items that are easy to fix and to provide consumers with the knowledge and materials (e.g., instructions, diagnostic tools, spare parts) necessary to complete repairs themselves or via independent third-party repair shops (Hernandez et al., 2020).

Despite efforts by companies such as Fairphone to encourage user engagement in product lifespan extension strategies, the occurrence of product repair in daily life continues to diminish (Sabbaghi et al., 2017). In addition, a recent report revealed that SMEs in the European Union do not consider designing products that are easier to repair among the top strategies planned for implementation in the near future (European Commission, 2022). As systematic support from companies is rare in practice, and DIY repair and upgrade typically depend on users' own efforts, online and offline platforms such as iFixit and repair cafés fill the gap by offering open-source guides, tools, and opportunities for collaboration.

Over the last decade, both the design and business domains have witnessed an increase in studies focusing on repair from the user perspective. These studies primarily focus on factors affecting repair decisions, such as barriers and motivators (Lefebvre et al., 2018; Magnier & Mugge, 2022; Sonego et al., 2022; Terzioğlu, 2021), creative attributions and product stewardship (Scott &

Weaver, 2015), the role of ownership and emotional attachment (Mugge et al., 2005; Schallehn et al., 2019; Wastling et al., 2018), product care behavior (Ackermann et al., 2021; Gregson et al., 2009), resources supporting self-repair processes (McQueen et al., 2023; Sandez et al., 2023), and the role of consumer practices and psychological obsolescence in repair (Jaeger-Erben et al., 2021). However, existing research has failed to identify the factors influencing user participation in collaborative repair and upgrade processes when they are facilitated by companies. Therefore, further investigation is needed to understand how companies can improve collaboration with users during product repair and upgrade activities.

This study aimed to investigate user perceptions when their own repair and upgrade efforts are supported by companies who design repairable products and provide extensive after-sales support, a process we refer to as *Facilitated DIY Repair* (FDR). Specifically, we sought to answer the following questions: i) *"What are users' perceptions toward the FDR experience?"* and ii) *"How are user perceptions toward these companies shaped?"* Improving the current understanding of user engagement and expectations during collaborative value creation could help companies develop services and products with longer lifespans through repairs and upgrades. This study also provides practical insights for companies operating in specific industries that could adopt FDR in the future.

This paper is organized as follows: first, we discuss the existing literature related to design for repair and upgrade, professional repair services, and DIY repair. Next, we explain the process and results of our in-depth interviews and desktop walkthroughs. Finally, we present a discussion conceptualizing FDR and potential user roles, along with design and managerial implications.

Design for Repair and Upgrade

Contemporary products are becoming increasingly difficult to disassemble and repair, often due to decisions made early in the design and manufacturing processes that result in non-removable components, glued attachments, and the need for special tools (Hernandez et al., 2020). Design for repair strategies include increasing product attachment, trust, adaptability, upgradability, component durability and longevity, standardization of compounds and joints, and ease of disassembly and reassembly (Bakker et al., 2014; Mugge et al., 2005; Nußholz, 2017).

The modularity and upgradability of components and subsystems are essential design features that improve both professional and DIY-repair potential (Amend et al., 2022; Roskladka et al., 2023), extend product lifespan, and enhance companies'

Serkan Bayraktaroğlu is an assistant professor of Industrial Design at Istanbul University. He holds a bachelor's degree in Industrial Engineering and master's and PhD degrees in Industrial Design. Serkan's research interests include design innovation, circular economy, eco-social design, and sustainable consumption. He is currently researching the role of design in influencing user behavior for the transition to a circular economy.

Elif İdemen is an assistant professor of Industrial Design at Istanbul University, Türkiye. She holds a PhD in Marketing, and master's and BSc degrees in Industrial Design. Her research interests include design management, product design, consumer behavior, and strategic marketing. Her work has been published in journals such as *Journal of Services Marketing*, *Review of Managerial Science*, and *Journal of Consumer Behaviour*.

sustainability performance (Zikopoulos, 2022). However, it should be noted that product modularity and upgradeability may also cause a rebound effect in terms of environmental impact due to consumers replacing subsystem components with greater frequency (Agrawal & Ülkü, 2013). Therefore, influencing user repair and upgrade decisions requires additional process innovation through service activities (Amend et al., 2022). Moreover, facilitating fault diagnosis is an essential step in the DIY-repair process and has been shown to influence users' willingness to engage in self-repair (Arcos et al., 2021, van den Berge et al., 2023).

From this perspective, design strategies should be based on a better understanding of the user and the concept of repair as both a professional and a DIY practice.

Professional Repair Services and DIY Repair

To address diminished product performance or the need for upgrades, companies often provide after-sales services and warranties, but decisions regarding the repair, upgrade, or replacement of the product are largely customer-driven. While European consumers are generally receptive to circular economy practices, with 64% willing to consider repair, the majority never rent or use second-hand products (Cerulli-Harms et al., 2018), and only 40% of Western consumers overall consider repair options (Magnier & Mugge, 2022). Most studies focus on these Western users, despite the fact that consumers in developing countries are more likely to favor repair (Sonego et al., 2022).

During a product's warranty period, utilizing authorized repair services is usually regarded as a safer and more convenient alternative to other repair options (Laitala et al., 2021). Additionally, independent repair shops (unauthorized services) and exclusive services (such as parcel pick-up, on-site repair, and custom services) require minimal user effort. Ultimately, several factors influence whether a user decides to utilize repair services, including the quality, age, and condition of the product, repair costs, the rate of unsuccessful repairs, and a limited availability of repair infrastructures (Laitala et al., 2021; Sabbaghi et al., 2017). The amount of travel time required to reach a service provider and the level of trust a user has in a given provider also play a role (Fachbach et al., 2022). Unpredictable service times and costs have been identified as inconveniences that create frustration and a lack of trust among consumers towards repair shops (Lefebvre et al., 2018; McCollough, 2009; Sabbaghi et al., 2017).

Some users, either due to personal preferences or a lack of professional support, may opt to handle repair and upgrade tasks themselves, or otherwise seek help from experts, repair communities, and other online and offline resources. Limited company support, such as a lack of instructive materials and services, may hinder the convenience of DIY-repair performance (Sandez et al., 2023). Repair cafés offer support to both novice and expert repairers by helping them to learn about and fix products while providing opportunities for socialization through dedicated spaces and equipment (Madon, 2022; van der Velden, 2021). iFixit, a repair portal providing free step-by-step instructions, spare parts, tool sales, and community support, helps users repair a wide range of products (see Figure 1).
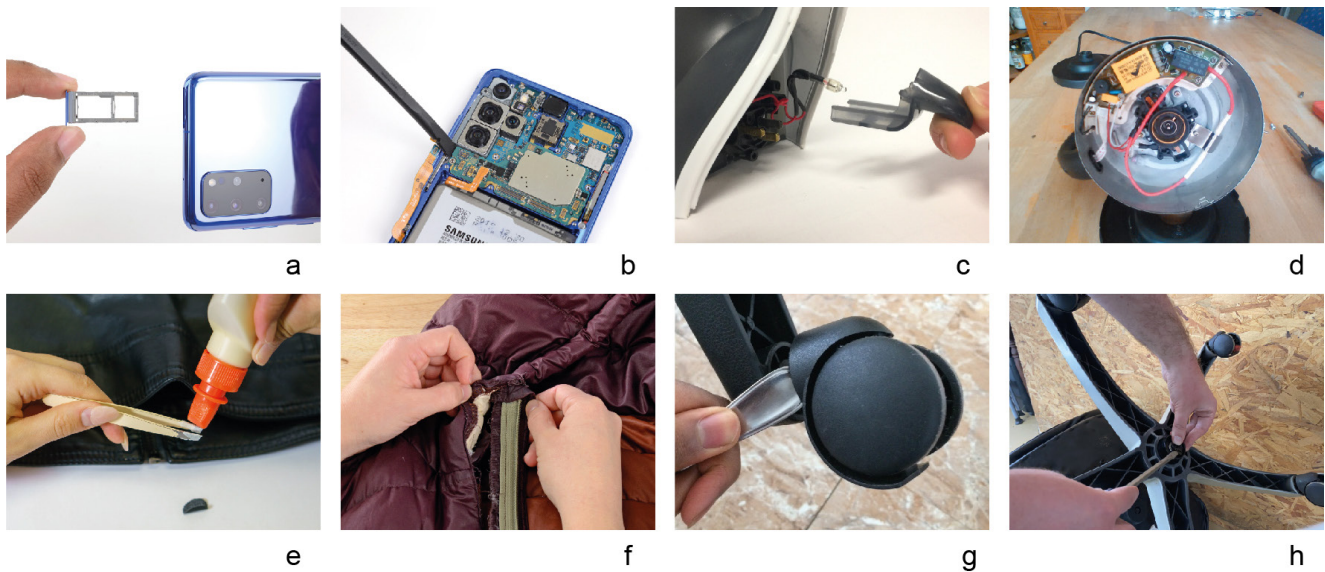
Figure 1. Sample photos of DIY-repair instructions created by iFixit users.
a) Replacing a SIM card tray (Thiruma, 2019a); b) Replacing a broken rear camera (Thiruma, 2019b); c) Fixing a tea kettle switch (Moll, 2017); d) Replacing a kettle's thermal cutoff fuse (Henderson, 2015); e) Fixing a damaged jacket (Castillo, 2023); f) Replacing the main zipper of a jacket (McCrigler, 2012); g) Replacing a broken wheel on an office chair (Dhorre, 2021); h) Replacing a lift cylinder on an office chair (Kay, 2022). All iFixit content is licensed under the CC BY-NC-SA 3.0 license.

Such initiatives are evidence of users' need for support in their repair activities. The act of consumers repairing their belongings is referred to as "DIY repair" or "self-repair" (Mashhadi et al., 2016). In this paper, the decision to repair is discussed not only as an alternative to replacing a product but also as a way of extending a product's lifespan, which is closely connected with maintenance and upgrade.

Current research primarily addresses the motivations and barriers affecting consumer decisions towards repair or replacement in terms of individual user characteristics, attitudes, and worldviews, or societal norms (Dermody et al., 2020; Korsunova et al., 2023; McQueen et al., 2023; Roskladka et al., 2023; Sonego et al., 2022). Other studies have explored the influence of product specifications, design features, different product categories (Güsser-Fachbach et al., 2023; Korsunova et al., 2023; Roskladka et al., 2023), the availability of spare parts and tools, the availability of authorized and independent repair services, and the role of other actors such as governments and

NGOs (Hernandez et al., 2020; Roskladka et al., 2023). Additional factors, such as a user's community, family, and friends (Gobert et al., 2021), as well as the time, effort, and knowledge required to make such decisions, have also been investigated (Ackermann et al., 2018; Russell et al., 2023) (see Appendix A).

In addition to a growing number of companies supporting product repairability, such as Apple's Self Service Repair program (Apple, 2022) and Nokia's repairable phone collaboration with iFixit (Finney, 2023), other initiatives also follow an FDR approach and have the potential to serve as viable business models. Fairphone, a company that designs modular phones that are easy for users to repair and upgrade, provides online diagnostic tools and video instructions (Zwicker et al., 2023). Clothing company Nudie Jeans offers consumers access to dozens of repair shops worldwide, and in cases where a repair shop is inaccessible, the company provides repair tools and replacement parts to support users' self-repair efforts (Briguglio et al., 2021) (see Figure 2).
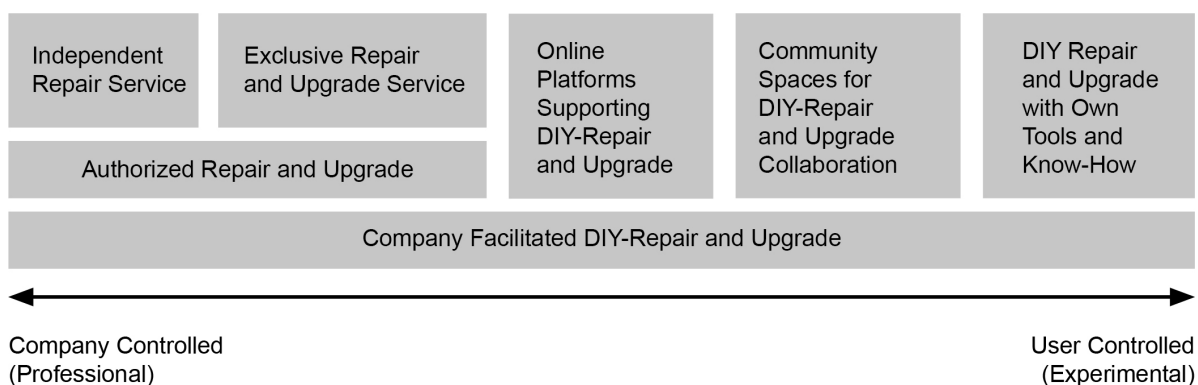

Figure 2. Repair and upgrade options.

Increasing customers' willingness to repair requires creative solutions and collaboration between manufacturers and consumers (Korsunova et al., 2023). Some users view the act of repair as vital, but they may feel ashamed to use repaired products due to the socioeconomic perceptions associated with them (Rogers et al., 2021; Tezioğlu, 2021). By offering collaborative services that aim to extend product lifespan, companies can help to eliminate the negative stigma around repair.

Value Co-Creation for Repair

Companies often play in role in users' self-repair efforts; for example, by providing them with assembly/disassembly manuals for modular furniture, failure diagnosis guides for home appliances, or the additional buttons/threads sometimes included with clothes. However, this study focuses on more intensive and continuous collaboration between companies and users, such as value co-creation efforts for prolonging product lifespan. In this context, a DIY-repair-oriented value proposition would include (i) designing and delivering products that are modular, repairable, upgradable, and easy to disassemble, making failure diagnosis easy for users; (ii) increasing users' access to spare parts and tools; (iii) enhancing the DIY-repair experience through extensive instructions; and iv) enabling user involvement in the design and development of products and services.

According to the traditional value exchange model, companies are responsible for designing, developing, delivering, and repairing goods, while consumers are considered mere passive receivers of value (Prahalad & Ramaswamy, 2004). However, with the rise of service-dominant logic, consumers have come to be recognized as active participants in value co-creation (Lusch & Vargo, 2006), which aims to capture the evolving relationship between companies and customers as their roles are continually redefined. This can be achieved through co-production, co-development, and co-design (Saarijärvi et al., 2013). Co-creation in the design domain leads to changes in design methods, content, and team composition, influencing tools and methods and blurring the line between design and research (Sanders & Stappers, 2008).

Prahalad and Ramaswamy (2004) emphasize that co-creation does not simply mean transferring or outsourcing certain activities to customers, nor does it just refer to improved customization; instead, it entails meaningful and sensitive interactions in which the consumer's co-creation experience becomes the foundation of value. Although this definition may appear somewhat broad, existing research on the consumer's role in value co-creation generally focuses on design, engineering, and manufacturing (Prahalad & Ramaswamy, 2004). Meanwhile, the use-phase and end-of-life stage, in which consumer decisions regarding the repair, upgrade, replacement, or discard of a product typically occur, have been neglected. Sustainable smartphone enterprise Fairphone provides an innovative example of value co-creation by offering proposals such as community-driven design contests and 3D printer-enabled local production to increase customer engagement in collaborative processes (Kortmann & Piller, 2016).

Despite such proposals, convincing users to engage in collaborative repair or upgrade efforts can be challenging.

Initiatives such as those established by Fairphone and MUD Jeans encourage commitment from sustainability-minded consumers based on transparent and fair practices (Briguglio et al., 2021; Haucke, 2018; Zwicker et al., 2023) and an emphasis on the long-term use of their products (Amend et al., 2022). Nevertheless, profit-oriented initiatives may not easily achieve such commitments.

In this study, we proposed FDR as a co-creation process for product maintenance, upgrade, and repair within a novel consumer-business engagement framework, with the goal of exploring the nature of a future repair service aligned with circular economy principles.

Methodology

In this study, we adopted an exploratory qualitative approach to investigate (i) user perceptions about companies that design repairable products and provide FDR, and (ii) how users' perceptions of these companies and the FDR experience are shaped. Due to limited information on user perceptions of repair-oriented businesses, we initially utilized the grounded theory approach via semi-structured in-depth interviews. Next, we conducted an analysis of the interviews and desktop walkthrough (DW) sessions to obtain a better understanding of the overall FDR experience, including user preferences, perceptions, and roles. Details regarding the sample, data collection, and experimental procedure are explained in the following section.

Sample and Data Collection

This research was conducted in Türkiye, where there has been an observable increase in repair, maintenance, and refurbishment initiatives due to ongoing economic challenges (NTV, 2022), supporting the notion that consumers in developing countries may have a greater tendency to favor repair decisions (Sonego et al., 2022). Participants were selected from Istanbul, a metropolitan city with a diverse population representing various cultures.

In-Depth Interviews

The authors of this study used purposive theoretical sampling (Glaser & Strauss, 1967) to select participants based on their potential to provide information relevant to the research objectives. Data collection concluded when semi-structured in-depth interviews yielded no additional data, indicating theoretical data saturation (Glaser & Strauss, 1967). The resulting sample consisted of 13 participants (6 males, 7 females), ranging in age from 24 to 59 years old (see Table 1).

Desktop Walkthrough (DW)

Purposive sampling was used to select participants from among 55 university students (9 male, 46 female) who participated in a survey exploring five different user roles identified during the interview findings (see Appendix B). The resulting sample comprised 10 participants (3 male, 7 female) ranging in age from 18 to 20 (see Table 2).

Table 1. Interview participant characteristics.

	Participant	Age	Gender	Occupation
1	Participant A	55	Female	Housewife
2	Participant B	59	Male	Retired Technician
3	Participant C	28	Female	Forest School Leader
4	Participant D	33	Male	Academician (Finance)
5	Participant E	32	Male	Psychological Counselor
6	Participant F	33	Male	Engineer
7	Participant G	30	Female	Historian
8	Participant H	30	Female	English Teacher
9	Participant I	33	Male	Science Teacher
10	Participant J	41	Male	E-commerce manager
11	Participant K	24	Female	Designer
12	Participant L	46	Female	Secretary
13	Participant M	26	Female	Aviation Maintenance Technician

Table 2. DW participant characteristics.

	Participant	Gender	Role
Session 1			
1	Participant N	F	C
2	Participant O	F	C
3	Participant P	M	D
4	Participant R	F	C
5	Participant S	F	B
Session 2			
6	Participant T	F	D
7	Participant U	F	C
8	Participant V	M	C
9	Participant Y	M	B
10	Participant Z	F	C

Procedure

In-Depth Interviews

Semi-structured interviews were conducted face-to-face and via Zoom, each lasting approximately one hour, and were recorded for transcription with the permission of the participants. The interview protocol for this study consisted of four main questions, which were augmented by additional questions used to gain deeper insights and encourage elaboration (see Appendix C).

Initially, the authors created fictional companies representing four different product categories: electronic products such as smartphones and laptops; small electrical appliances such as vacuum cleaners and irons; fashion products such as clothing and shoes; and furniture such as tables and chairs. Interviews began with one of the four companies being described as designing easily repairable and upgradable products and assisting users with product maintenance, repair, and upgrade in their homes.

Participants were informed that some spare parts, tools, instructions, or guides for the repair, maintenance, and upgrade activities were provided with the product, and users could request repair services from the company when needed. The participants were then asked questions as determined by the interview protocol to get them thinking about the first fictional company.

Key inquiries focused on participants' past experience with repair activities, perceptions of the fictional company supporting FDR and its products, and opinions regarding the price of such products. After a participant answered all relevant questions about one company, they were presented with the same set of questions about another company operating in a different sector. Participants were asked to provide their opinions on each of the four fictional companies separately. Additional explanations were provided as needed in response to participants' questions about these companies. Throughout this process, our goal was to learn about participants' emotions, thoughts, and perceptions about company support for DIY repair and comprehensive repair services for the four distinct product categories. The authors then individually analyzed each interview, and the findings were used to generate the main themes and conceptual model for the study.

Desktop Walkthrough

A desktop walkthrough (DW) is a tool for exploring, prototyping, and co-designing experiences (Auricchio et al., 2022) and serves as a kind of design game, enabling the simulation of scenarios and journeys to collect user perspectives (Blomkvist et al., 2016). In this study, DW was used to explore user appraisal mechanisms and potential outcomes using eight repair scenarios. Two identical DW sessions were conducted, each lasting 90 minutes and consisting of five participants. Sessions were recorded for transcription using video and audio after permission was granted by all participants involved. Four fictional companies and scenarios comprised of eight user journeys were created, incorporating easy (JxE) and difficult (JxD) repair tasks collected from iFixit and which corresponded to the product categories used in the interviews (see Table 3). Each participant was asked to role-play their journey for each task on the board, which was designed to simulate various options including authorized and independent repair shops, repair cafés, and spare part markets (see Figure 3). Predefined questions were posed to each participant to assess their evaluation of each task, their expectations about FDR, and their views on the company. Additional discussion among participants was encouraged. Further details regarding the procedure can be found in Appendix D.

Table 3. DW product repair tasks.

Product Category	Easy Task	Difficult Task
1) Personal Digital Devices: Mobile Phone	J1E: The SIM card was not functioning at times and now it is not recognized by the phone	J1D: Rear camera of your phone is not functioning
2) Small Home Appliances: Kettle	J2E: The switch of the kettle is too loose, and sometimes does not function	J2D: You have plugged the kettle in, but it does not heat, and the light is not on
3) Fashion Products: Faux Leather Jacket	J3E: There is a crack in the leather of the arm of your leather jacket	J3D: The main zipper is not working properly
4) Furniture: Office Chair	J4E: The wheel of the chair is broken	J4D: The chair's height can no longer be adjusted

Figure 3. Pictures from DW sessions.

Data Analysis

In-Depth Interviews

Audio recordings were transcribed verbatim, and the data were coded using MAXQDA 2022. Once the initial data analysis was conducted to identify preliminary categories, we then returned to the field to obtain missing information and additional data for underdeveloped categories (Creswell, 2012). Following the grounded theory approach (Glaser, 1998), a substantive (or open) coding process was initially used to identify all potential concepts within the transcribed data. Next, selective coding was employed to categorize relevant concepts using low-level codes. Finally, during the theoretical coding process, higher-order categories were identified and relationships between them were proposed to establish a conceptual model (see Figure 4).

Desktop Walkthrough

During the DW sessions, one of the authors took notes on the participants' responses to scenarios while the other supervised the process. Data from the audio transcriptions were coded manually. Concepts and codes derived from DW session analysis were integrated into the interview analysis results.

Results

Analysis of the data revealed 228 concepts highlighting 25 lower-order categories (see Appendix E). As illustrated in Figure 4, we found that companies that offered FDR options enhanced their reputation among users based on the product category-driven evaluation criteria through multiple mechanisms, ultimately boosting users' sense of empowerment.

Empowerment Boosting Mechanisms of FDR

Boosting Interest in Repair and User Perceptions of Repair Capabilities

Interviews and DW sessions revealed that the company-facilitated repair process increased participants' interest in repair. Multiple participants used the term "authority" during DW sessions, reflecting their uncertainty about whether their intervention with the product would affect its warranty coverage, an issue often encountered with companies in developing countries where consumer protections may be lacking. As confidence in company support and product repairability grew during DW sessions, participants became increasingly interested in repair and came to perceive themselves as having the right and authority to disassemble and repair a product. As Participant R stated: "The company thinks I can do the repair. It should have facilitated the repair process. So, I will give it a try."

The interviews also revealed that a perceived lack of dexterity and self-confidence in dealing with physical objects are significant barriers preventing users from engaging in self-repair, as previous research has suggested (Fachbach et al., 2022; Terzioğlu, 2021). Our findings indicate that facilitating repair by providing tools and guides can empower users to engage in repair activities and give them the self-confidence they need to
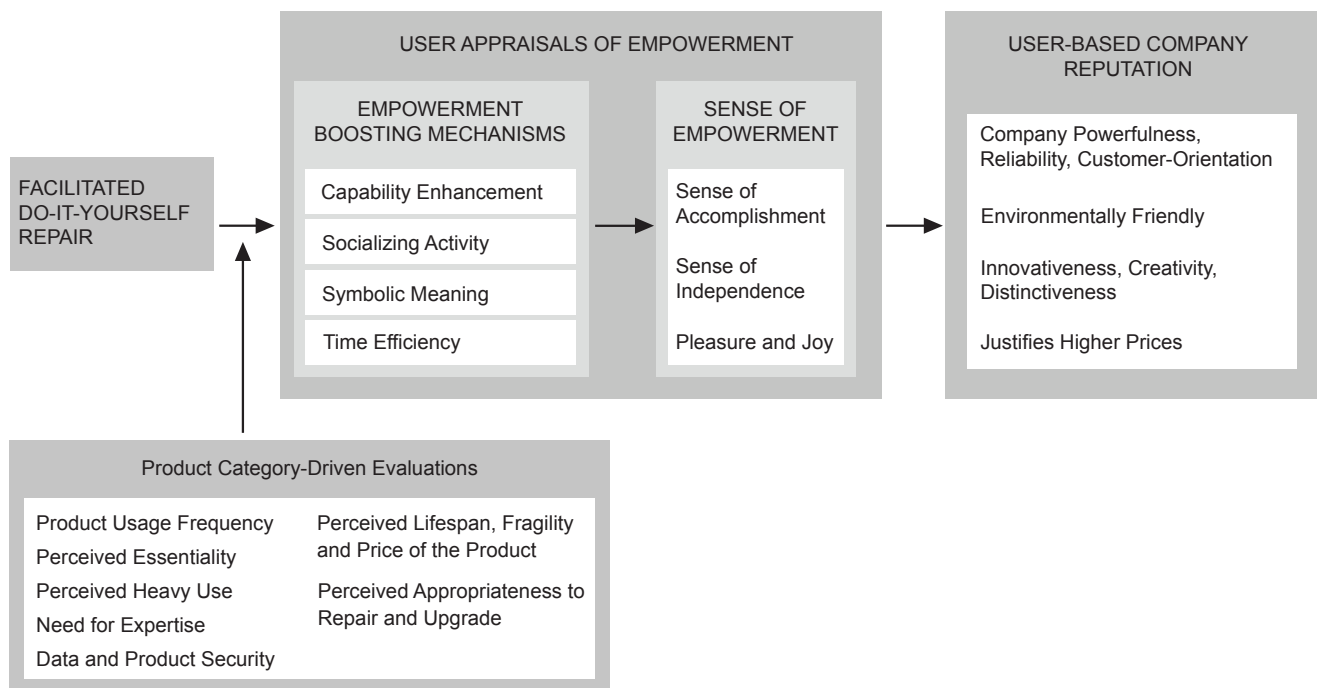
Figure 4. Conceptual model of Facilitated DIY-Repair.

attempt DIY repair. During the DW sessions, all participants were convinced to try FDR for easy tasks in each product category, and six participants expressed that following a successful FDR experience, they felt encouraged to attempt more difficult tasks such as J1D and J2D. Participants assumed that companies offering supportive materials and services would be of a higher quality but may still lack end-user perspectives and alternative solutions. Three participants stated that they would reference YouTube or other forums to better understand a repair process instead of solely relying on the materials provided by the company.

FDR as a Socializing Activity

Responses from two participants who are not actively engaged in work life led us to conclude that facilitating repair activities with tools, spare parts, or guides could serve as an enjoyable activity for users in their spare time. Participant B noted, "I am retired. I have spare time. I would prefer to repair by myself with the help of supporting equipment. In this way, I would have a good time."

> DIY repair may also be practiced as a collective activity among family members or groups of friends (Gobert et al, 2021). Similarly, in the DW sessions, all participants stated that if they were confused by a task, they would likely consult with a family member or friend whom they trust and view as more experienced in repair, essentially resulting in collaborative FDR.

> ...the table was rusty, we bought paint with my husband and painted it, it was nice. I mean, maybe we didn't put much effort into it, but in the end, something good came out…That atmosphere was sincere…we did it together, and we created something new by changing an existing product. Of course, it was fun. (Participant H)

Attributing Symbolic Meaning to FDR

Four participants, due to their sensitivity to sustainability issues, identified FDR as an opportunity to commit to an environmentally-conscious path and even offered to voluntarily advocate for companies that promote FDR policies. Previous research identified sustainability sensitivity as one reason why users purchased Fairphone products (Zwicker et al., 2023), and similar mechanisms appear to increase support for companies offering FDR options.

> I would definitely prefer this firm's products. I will also share it on my social media. [Why?] Because I want people to prefer these kinds of products. We should praise sustainability anymore. I am getting bored of seeing those shopping links in Instagram posts. Let's be proud about the products we have been using for 10 years. (Participant C)

FDR as a Time-Efficient Process

The waiting times and procedures involved when getting products repaired pose substantial challenges to users—even for those interested in repair (Hernandez et al., 2020). Similarly, 13 of the participants in our study emphasized that FDR is "time-saving" compared to the obligatory steps involved in the professional repair process, such as transporting the product to the repair service location, explaining the failure to technicians, and needing to leave the product at the repair facility—sometimes for days. However, such attitudes may stem from inefficient repair services experienced by the participants in Türkiye.

> If it is something that I can fix at home, I would like to do it myself, rather than taking it to the service. [Why?] I get it done faster. Otherwise, you will take the product to the repair service, they

will say the service is too busy, for example, they will say we can deliver the product one week later or ten days later…I prefer to repair it myself. (Participant A)

For products perceived as essential for daily activities, participants overwhelmingly preferred not to be limited by repair service schedules. It was summer when my refrigerator was broken. Refrigerator is a product that I need constantly. The repair service said we are too busy today. I mean, this state of being dependent on someone was really annoying for me. (Participant G)

Thus, FDR potentially alleviates time-efficiency concerns and encourages users to repair their products, with some caveats. For instance, DW sessions revealed that (i) participants care about the time required to procure the additional parts required for FDR, and (ii) the time participants are willing to devote to failure diagnosis and repair varies depending on the kind of product and how indispensable it's considered to be. In one instance, using a mobile app or contacting a call center for failure diagnosis was seen as a more efficient approach than reading a guidebook.

Sense of Empowerment

Interview findings revealed that all but one participant associated FDR with positive emotions such as pleasure, enjoyment, and a sense of accomplishment. This aligns with existing literature suggesting that feelings of achievement and enjoyment are the main outcomes of completing DIY projects (Wolf & McQuitty, 2011). The one dissenting participant emphasized that she preferred to receive services in general and wouldn't want to deal with repairs herself. For the rest of the participants, however, the provision of guides, tools, and spare parts with the product alleviated their concerns about needing to obtain the items necessary to complete repairs. Moreover, following step-by-step instructions was likened to playful activities, such as building with LEGO blocks. As Participant G explained, "Repairing a product by myself or contributing to its revival will give me happiness because it will feel like I've accomplished something."

According to Participants H, N, and Z, the provision of extra materials was particularly appealing in the context of fashion products. They found it intriguing not only in terms of product repairability but also for the possibility of using such materials for other products or using the provided instructions to develop new techniques for creative experimentation and bricolage. Said Participant H, "I liked the idea. It's enjoyable, like a hobby. For example, in my spare time, I would use the tools and spare parts given not only to repair products but also to create new things."

Participants sometimes showed particular interest in specific product categories, driven by curiosity about new trends or a desire to engage with products that others might find boring or problematic. Such self-identification may influence perceptions of the potential benefits they would derive from the FDR process in the context of a specific product category.

We identified that a sense of accomplishment and autonomy substantially contributed to participants' feelings of pleasure and happiness, especially among female participants. Engaging in

FDR enables a sense of empowerment similar to that associated with other DIY activities. Research has shown that such activities can increase women's sense of independence by challenging traditional gender roles and enhancing feelings of self-worth through successful task completion (Wolf et al., 2015). Existing literature underscores the influence of gender roles in garment and electrical product repair tasks (McQueen et al., 2023; Young & Rosner, 2019), and in Türkiye, technical tasks tend to be associated with men, while household-related tasks are usually associated with women (Yılmaz, 2018). Our findings suggest that for women, successfully repairing or upgrading an electronic device, small home appliance, or piece of furniture not only provides joy but also a sense of accomplishment and pride. As Participant G stated, "It will be good for me as I will have the feeling of being able to handle my own job without being dependent on another person…I will feel free," and Participant N expressed a similar sentiment during a DW session: "I want to fix the other products now that I have self-confidence. I want to share this experience with my friends. I am proud of what I do." This sense of accomplishment was noted by several participants:

This (self-repair) makes me feel good: doing by myself without any support from others. Additionally, I don't like women being perceived as incapable of doing their own repair work such as perceiving not being capable to change the tires of the car. I enjoy the repair activity. (Participant C)

Several socio-cultural barriers affecting women were also identified during the study, a discussion of which is particularly relevant in the context of developing countries. As violence against women continues to be a prevalent issue in Türkiye (Güneş & Ezikoğlu, 2023), all female participants (with the exception of Participants K and U) indicated during interviews and DW sessions that they were reluctant to interact with repair technicians while at home alone and emphasized the need to be accompanied by a friend or family member during such encounters. A consensus emerged among all female participants that FDR provides a sense of independence, alleviating concerns about potentially worrisome or dangerous situations.

Since I'm a female, my family always gets anxious when a mechanic comes to the house. But if I repair my products myself, my family will not have this anxiety, I will not feel the need to call a friend to my house because of a repairman, so I will feel free. (Participant G)

User-Based Company Reputation

FDR-Supporting Companies as Powerful, Reliable, and Customer-Oriented

Participants expressed that comprehensive FDR services can only be realized by powerful companies with strong design and production capabilities that allow them to anticipate and address users' product-related problems. As such, designing repairable products is perceived as the result of considerable effort during both the design process and when providing after-sales services.

Additionally, the interviews revealed that FDR-supporting companies are perceived as more likely to guarantee the quality of their products and more willing to help users when a problem with a product arises. A company that quickly responds to issues creates the impression of being a problem-solving facilitator that makes life easier for its customers. Participants assumed that for customer-oriented companies, serving users with high-quality and long-lasting products is an integral part of their business models.

> The company relies on its products, so it allows you to open them and see inside. Besides, it has standardized it well enough that anyone can do it without any technical knowledge. So, they consider your interest and have self-confidence. (Participant F)

It was also clear that FDR-supporting companies improved their user-based reputation among participants. User-based company reputation is not only a gauge of the reliability and strength of a company but also measures whether consumers perceive it as having customer-oriented, pro-social, and pro-environmental positions (Walsh et al., 2009). Our findings align with previous research on consumer perceptions, such as the work of Stanaland et al. (2011), which explains how socially responsible actions improve a company's reputation in the eyes of its customers.

However, in both DW sessions and interviews, two participants expressed skepticism about companies that provide guides, tools, and spare parts with the initial product purchase, reflecting concerns that have been explored in prior studies which suggest that promoting repairability potentially increases users' concerns about a product's susceptibility to malfunctions (Van den Berge et al., 2023). As a result, FDR provisions gave skeptical participants the impression that the product may actually be more prone to failure. As they saw it, only essential items should be provided with the product at the time of purchase. Receiving additional parts only when necessary also eliminates the problem of needing to store them for potential future use.

> I would think the product will be frequently broken. Why did the firm give that repair equipment? Doesn't it trust itself? First impression is bad. But when it is broken and I call the customer service, if they say we provide you with some tools and spare parts, this will have a more positive effect on me. [What do you think about this company as you describe?] I would say it is a company that cares about customer satisfaction. And a company stands behind its products. I think such offers are important after the warranty expires. It is important how the company supports you after the product warranty expires. The company is responsible for the repair of the product in scope of the warranty. Why should I keep those spare parts, guides, and tools for two years? (Participant D)

Participants also emphasized the importance of companies advertising and promoting the positive aspects and benefits of repairable products for users in order to alleviate concerns about product reliability. As Participant U explained, "Still, of course, advertising is important because I don't want to buy a phone from a random company that I don't know the name of…But I could buy a task chair, for example."

FDR-Supporting Companies as Environmentally Friendly

Participants perceive FDR support as a characteristic of environmentally-conscious companies, using terms such as "sustainability-oriented" and "environmentally friendly" to describe companies that promote FDR.

> ...because of its sustainable character, I like it very much… Nowadays everything is based on excessive consumption…I mean, I get the message that I can use this product for many years…I feel that their products are not produced to discard. (Participant C)

Providing sustainable products (i.e., those produced from recycled materials) causes companies to be perceived as warm and cooperative entities with positive intentions toward their customers and society in general (Grazzini et al., 2021). Our data suggest that the warmth and competence framework (Kervyn et al., 2022) may explain how FDR improves user-based company reputation: by supporting both perceptions of a company's warmth (including perceptions of being a pro-environmental, pro-social, customer-oriented company) and competence (including perceptions of being a company that produces high-quality products and provides additional services, as well as being strong and having high design and production competencies) in the minds of its users.

FDR-Supporting Companies as Innovative, Creative, and Distinctive

Our participants stated that the fictional companies initially appeared innovative and creative. However, when asked whether they had experienced similar satisfactory repair services, most found it difficult to provide an example. This was not particularly surprising, since products available in the Turkish market are not typically designed for repairability, companies that facilitate such repair services do not exist, and platforms such as repair cafés and iFixit are not familiar to Turkish consumers. Since "newness" largely shapes consumer perceptions of company/brand innovation (Shams et al., 2015), the absence of such practices in a given product category likely led participants to consider any FDR support as innovative and creative. This was the view of Participant P, who stated, "Designing products simple enough to repair and developing a distinctive system requires creativity." Another participant further elaborated:

> I think these firms are innovative because there is no company doing something like that. They are trying to do something new and interesting. Even though I don't like their products or don't buy them, I would follow the products of the firm. (Participant F)

Although users' novelty-seeking attitudes have been identified as a barrier to extended product use (Jaeger-Erben et al., 2021), perceptions about companies' innovativeness also create excitement for users and provide an opportunity for user-firm interactions (Kunz et al., 2011). According to our findings, companies supporting DIY repair are perceived as distinctive, arousing curiosity and encouraging users to further examine them and their products.

…it would be attractive to me…It is a distinctive feature of a company to meet the need for repair. It would arouse curiosity, so I would go to the store and examine its products. I would like to know how they organized [these] repair issues and how they can help me when I have a problem. (Participant E)

Despite perceived innovativeness, one participant also expressed doubts about the viability of such a strategy, since making products that are susceptible to user interference could cause further issues and increase costs for the company: "… Turkish users would not obey instructions often" (Participant P).

FDR Justifies Higher Prices

According to participants, products from FDR-supporting companies would likely be more expensive than those of competitors due to additional design and manufacturing investments.

> It promises you a high-quality product that you can use for a longer period of time. Therefore, it will actually sell less product[s]. That's why I wouldn't mind if it was more expensive than the other products. I expect that. [Would you prefer to buy?] One hundred percent. I strongly believe that I will use the product for a longer period of time. (Participant C)

Although modular, repairable, and upgradeable products may cost less over their lifespan, and environmental concerns remain one of the major drivers of eco-friendly purchases, price consciousness is a critical negative factor affecting consumers' green purchase intention (Wijekoon & Sabri, 2021). Despite the anticipated higher prices of FDR products, participants still saw companies that provide such options as budget-friendly due to longer product lifespans and reduced service costs, positively influencing their likelihood of purchasing such products.

> It is a budget-friendly company. [Why?] Because when you call the repair service, even if they don't do anything, they get paid… Or I have to pay even for a problem that can easily be solved. But if it allows me to repair the product by myself I can solve simple things. (Participant L)

While most participants anticipated higher prices for FDR products, Participant V assumed that prices would remain largely unchanged, as sales of spare parts and tools would provide companies with a new revenue stream that would offset additional design and service costs.

Product Category-Driven Evaluations

Perceptions of Product Lifespan, Essentiality, and Frequency of Use

We defined the frequency of product use as the amount of time a user spends with a product during an average day. Participants believed that FDR would prove more beneficial for frequently used products such as mobile phones, which are seen as essential. Naturally, users prefer a quick fix for an essential product rather than having to leave it with a professional repair service for an extended period. Discussions during DW sessions also revealed

that such decisions depend on whether a failed *function* is considered essential. For instance, Participants U and V stated that rear camera failure (J1D) would not be as severe as a SIM card problem (J1E). As a result, they would tolerate more time-consuming FDR processes to address the J1D task, such as purchasing a camera module. Furthermore, when the spare parts required to restore an essential function (J1E) were lacking, FDR was viewed less favorably.

> When a product breaks down, I usually prefer to buy a new one. I don't want to deal with repair services. Indeed, to get a product repaired can take a very long time…But if I could fix it myself, if I had been provided with the repair kit, I could do it immediately when I needed it. Let's say the iron is broken today. I have to buy a new iron not to wait for the repair time because I use it every day. (Participant M)

Certain product categories, such as furniture, were described as heavily used compared to others. Such products are used over relatively longer periods during which carelessness—among other factors—leads to wear and tear. Participants expressed that FDR is more appealing when applied to these product categories in an effort to the extend product lifespan. "Household products are used a lot, so they wear a lot. That's why I prefer it to be supported or be able to fix it myself, as I think it will be financially advantageous" (Participant E).

Participants associated different product categories with different lifespans and were generally more interested in FDR for products associated with longer lifespans. Previous research supports such attitudes, as expectations about longer product lifespans and extended product use have been linked with positive repair decisions (Jaeger-Erben et al., 2021; Sonego et al., 2022). Similarly, our findings indicate that perceived price and product fragility also influence user attitudes about anticipated FDR benefits. However, it should be noted that our study did not explore differences between the FDR approach and professional repair services as they relate to these factors.

Perceived Appropriateness of Repair and Upgrade, and Need for Expertise

Some participants identified certain products as more suitable for maintenance (such as small electrical home appliances or furniture) or frequent upgrades (personal electronics), while others were viewed as impractical to repair (fashion products). Participant F found it difficult to imagine the design of modular clothing that could be upgraded, citing concerns that it would require synthetic materials and connection elements that would make the product superficial or uncomfortable. On the other hand, participants were interested in purchasing FDR-supported electronic products specifically because of their enhanced upgradeability and extended lifespan. These findings highlight the importance of FDR-supporting companies making efforts to clearly demonstrate the benefits of product modularity and repairability to users.

Consumer knowledge and skills have been shown to play a pivotal role in motivating repair behavior (Ackerman et al., 2018; Sonego et al., 2022), yet our data indicate that such factors

are often only relevant to specific product categories. During interviews and DW sessions, 16 participants initially expressed reluctance to intervene in electronic products despite having a general interest in DIY repair. As Participant J explained, "For electronic products, I prefer the company to undertake the repair process. Because electronic products require expertise. But I can repair products such as tables or chairs myself."

Participants who were hesitant to deal with a given task during a DW session sometimes stated a desire to seek help from an experienced friend or family member. It should be noted that sharing spare parts, repair tools, and other devices is a common phenomenon among friends, family members, and neighbors in the sociocultural context of Türkiye.

Data and Product Security Concerns

When it comes to electronic products, many consumers prefer to repair rather than replace them due to concerns about personal data and media stored on such devices (Sabbaghi et al., 2017). Similarly, participants in the present study preferred to be involved in the DIY-repair process in instances where safeguarding data stored on the product was considered particularly important.

> …all my information, my passwords, my photos…I don't want to give it to someone. Instead, if I can fix my computer, tablet, and phone…my privacy will be protected. Today, we hesitate to keep personal information in them, whether it is broken or stolen, we do not shoot photos sometimes. But when it is possible to repair myself, I will be more comfortable. (Participant G)

Three DW session participants recounted negative experiences with authorized repair services in which products became further damaged and with independent repair shops where valuable parts such as graphics cards were replaced with lower-quality ones. Due to a lack of robust legislation supporting consumer rights, such cases are not uncommon in Türkiye. From this, it may be concluded that consumers in developing countries stand particularly to benefit from FDR support, and pointing out a lack of consumer legal protections may prove a valuable strategy for convincing users of personal electronics products to engage in self-repair.

Conceptualization of FDR within the Framework of Value Co-Creation

The interview findings highlighted distinct user perspectives regarding the FDR experience, while the DW sessions provided a deeper understanding of the potential roles of the various actors involved throughout the process. These roles do not merely refer to the personal characteristics of individuals involved in the value co-creation process but represent protocols facilitating user engagement. As such, a user may assume different roles depending on the product category.

In a conventional professional repair service scenario, consumer participation in value creation is often limited to *self-servicing* tasks such as reaching out to a company, delivering a faulty product for diagnosis, and picking up the product once it has been repaired. The concepts of DIY repair and upgrade, however, can be seen as a specific form of *prosumption* driven by various motivations, including potential economic benefits, customization needs, fulfillment of craftsmanship, empowerment, self-sufficiency, personal learning, and opportunities for socialization (Alhashem et al., 2020; Wolf & McQuitty, 2011). Thus, we drew on our research findings and insights from the value co-creation literature to conceptualize FDR as a value co-creation process for repair (and upgrade), identifying several user roles involved in extending a product's lifespan (see Figure 5).

Passive value receivers tend to refrain from engaging in repair processes and prefer exclusive services such as on-site repair and parcel pick-up. Data from the interviews indicate that these "service receivers" are reluctant to embrace FDR, yet they may be willing to participate in specific areas of interest. For example, even though Participant K wasn't interested in repair, she still found dealing with furniture repair processes intriguing as a hobby. In total, eight of the survey respondents saw themselves as passive value receivers, but none wanted to participate in DW sessions.

Self-servicers typically view the manufacturing company as the main authority to be contacted for repair services or to express complaints (Participant S). Perceived risk is the most common obstacle preventing such individuals from participating in FDR processes, especially if they are unfamiliar with the product category. In such cases, they may seek assistance from a knowledgeable friend or family member, transforming FDR into a social activity (Participant Y). If they can be convinced that a repair process is relatively easy, they may attempt FDR with limited effort and knowledge, taking on simple pre-defined interventions requiring a minimal number of steps, such as replacing a battery or a damaged case on a cell phone. Successful completion of basic tasks boosts their self-confidence, increases feelings of joy, excitement, and pride, and encourages them to perform more difficult tasks, bringing them closer to the co-repairer role. The storage of additional materials poses another potential challenge for self-servicers. However, if supportive resources are not provided with essential products, they are more likely to rely on authorized repair services.
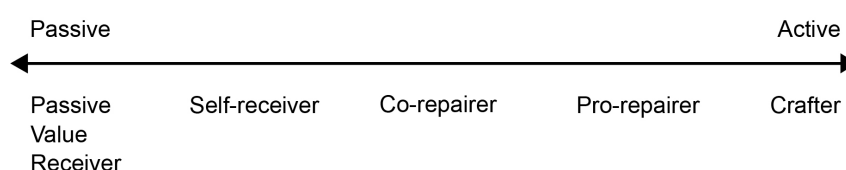

Figure 5. User roles during value co-creation for product lifespan extension.

Co-repairers tend to be interested in disassembling, repairing, and upgrading products from any category, provided they are convinced of their authority to intervene and find the quality and comprehensiveness of company-provided instructions and tools satisfactory. The perceived attractiveness of collaboration makes co-repairers a key target demographic for FDR-supporting companies. In addition to company-provided content, co-repairers are also interested in other users' repair experiences and may be willing to tolerate long wait times for the delivery of spare parts.

Pro-repairers often have a special interest in a specific product category but generally feel confident repairing and upgrading various kinds of products, with certain exceptions. For instance, Participants F and P expressed reservations about engaging in textile repairs, citing unfamiliarity with products in this category. Pro-repairers' main concern lies in understanding the company-defined limits of user intervention that affect warranty coverage. They are willing to leverage online and offline resources ranging from user-generated content online to items purchased at hardware stores. However, they are content to use their own supplies and tools for repairs and upgrades when possible; as a result, they may not always closely follow step-by-step instructions for failure diagnosis and repair (Participant P, for tasks J2 and J4).

Crafters are defined in the literature as consumers who purchase resources from the marketplace to construct and personalize their unique creative outputs (Campbell, 2005). Although our findings did not explicitly reveal the crafter role in value co-creation for repair and upgrade, we drew upon existing literature to speculate about its role in this context. Two survey respondents identified themselves as crafters but were reluctant to participate in DW sessions, preventing further investigation into this role. Nonetheless, we would expect crafters to be interested in experimenting with frugal innovations and bricolage, not only using existing tools and components but also designing and developing new tools and components with their own materials. Depending on the product category, crafters may employ 3D printing or handcrafting. Instructions and tools restricting user experimentation would not likely appeal to these individuals.

As previously stated, we proposed FDR in this study as a type of value co-creation process for the maintenance, upgrade, and repair of products to explore the nature of a future repair service aligned with circular economy principles. The roles identified and described above could be utilized by companies to guide engagement and help them design more effective products and services.

Conclusion and Discussion

This paper set out to enhance understanding of eco-innovative collaborations between consumers and companies with the aim of extending product lifespans. To achieve this, the study (i) analyzed user evaluations of the repair process when they are supported by companies to perform product repairs (FDR) through the provision of additional guides, tools, and spare parts, and (ii) investigated consumer perceptions about companies that facilitate repair processes by designing repairable products and providing additional materials for repair and upgrade.

Additionally, we proposed a conceptual model summarizing how users' appraisal mechanisms of FDR elicit a sense of empowerment and affect the user-based reputation of FDR-supporting companies. This model was based on insights garnered from interviews and DW sessions, utilizing fictional companies spanning various product categories which adapted prominent features from similar business cases (Fairphone, Nudie Jeans, etc.). This allowed us to better understand how user evaluations can change depending on specific contexts, product categories, and user roles. Five distinct roles were identified, shedding further light on the various ways consumers engage with companies.

Design and Managerial Implications

Consumer practices such as keeping products clean or lubricated, as well as general home repairs, have been identified as conservative practices aimed at extending product lifespan (Gregson et al., 2009). However, contemporary products are often designed to minimize user effort, as consumers often complain they lack time for such maintenance activities. For instance, the trend towards smaller and increasingly connected electronic devices has resulted in manufacturers using more embedded components that are inaccessible for disassembly or replacement to the average consumer, leading users to hesitate to attempt repairs. Consequently, user-product relationships may decline over time as consumers come to know less about the products they use.

The primary challenges associated with FDR implementation include designing repairable products and facilitative services, convincing users to engage in co-repair practices, overcoming negative stigmas associated with repair, and minimizing doubts about personal competency by ensuring all steps involved in a repair process are clear and understandable to users. Unlike products that allow users to practice DIY repair without any professional support, products designed for co-repair processes must clearly delineate limits for user interventions and provide supportive guidance and services designed to holistically address the entire repair process.

Implementing such a business model requires the design of "touchpoints" to stimulate intensive user engagement. Companies need to develop online and offline media resources, including websites, blogs, and printed guides to facilitate repair processes. Technological trends such as the Internet of Things (IoT), artificial intelligence (AI), and 3D printing can play a positive role in designing such products and services. Participants in this study expressed a desire to use mobile apps and access instructive videos for failure diagnosis and repair. AI, currently used for making devices smarter and easier to use, also holds significant potential for the development of supportive services. IoT may contribute by continuously monitoring a product's status, ensuring preventive maintenance is carried out in a timely manner and improving product care behavior. Given the need for an affordable spare part supply network (Mashhadi et al., 2016; van der Velden et al., 2023) and the vertical integration of companies in the supply chain (Hansen & Revellio, 2020), the analysis and management of B2B and B2C spare part logistics also stand to benefit from IoT technologies while improving users' access to spare parts.

Products within FDR's conceptual model are poised for optimal performance when they are designed to encourage users to prioritize preventive maintenance and care. This approach not only improves the user-product relationship but also reduces the risk of physical and emotional obsolescence. Design strategies play a pivotal role in changing users' attitudes and behaviors to enhance product care (Ackermann et al., 2021). In this context, FDR initiatives should provide users with additional materials and instructions not only to address total product failures but also to handle day-to-day product issues, ensuring that user-company collaboration extends beyond a product's end-of-life stage. Participants in DW sessions perceived some of the given tasks as minor failures (e.g., J4A and J4B) and stated that they would continue using the product for a period without fixing it. In such scenarios, FDR support might entail other features to persuade and motivate users to pay attention to their products, thus preventing more critical failures.

Modularity and upgradeability are essential features that enable the repairability of electronic products (Roskladka et al., 2023). In this study, participants expressed hesitation when it came to repairing electronic products, preferring to opt for upgrades. Therefore, companies that want to encourage FDR should also emphasize the potential for upgradeability (FDU–Facilitated DIY-Upgrade), especially for personal electronic products. However, such companies also need to consider the rebound effect, which could lead to increases in adverse environmental effects (Agrawal & Ülkü, 2013; Fischer et al., 2022). Moreover, modularity can sometimes result in products with extra weight or volume. Finally, products with improved modularity and upgradeability still need to meet users' aesthetic expectations in order to compete with commercially accepted, compact, sleek—but non-repairable—alternatives.

Users who are uninterested in repair or lack self-confidence can be motivated by tools and guides provided by the manufacturer. In this respect, designing user-friendly failure diagnosis guidance is crucial. Our findings indicate that users tend to prefer to use a mobile app rather than contact a call center to avoid social interaction. Some users find printed visuals easier to follow for repair instructions while others prefer watching videos. Thus, it is critical to provide assistance in various formats to cater to different types of users. AI-powered conversation-based mobile apps for failure diagnosis and gamified instructions encouraging users to engage in FDR with friends and family members can further enhance learning and collaboration, ultimately boosting user engagement. Additionally, actual user videos may be effective for convincing users that an FDR process can be completed successfully. This could entail the creation of a user community platform to help users overcome concerns about buying a product from an unfamiliar company.

Our findings suggest that clear tutorials encourage users to initiate FDR, but that the likelihood of users precisely following steps as predefined by a company may vary according to the cultural context. Living in a developing country where aftermarket parts and tools are readily available, labor costs are low, craftsmen are numerous, and non-professional product manipulation and bricolage are common practices, means that some users—

especially pro-repairers and crafters—are likely to develop their own approaches. Guiding users through the intervention process with clearly defined boundaries can be facilitated by design features such as instructive forms and the use of distinct colors and labels in product components and subsystems.

Companies offering FDR resources and support are perceived as reliable and customer-oriented due to their emphasis on extending product lifespan. However, these companies must carefully consider when to provide repair-related support. Including guides, tools, and spare parts with the initial product purchase may give consumers the impression that the product is liable to break down in a short time. On the other hand, users expect to have essential spare parts and tools available when needed to quickly address product malfunctions or failures. The perceived essentiality of a given product or function means that the length of time users are willing to wait for replacement parts or repair tools varies considerably. Thus, companies should consider the essentiality of their products and related functions when designing repair and upgrade kits.

Similarly, product care behavior largely depends on a product's perceived essentiality and price. However, the production and delivery of large quantities of spare parts can pose a storage burden for users and may not be economically viable for the manufacturer. Therefore, distinguishing between common and rare failure and upgrade scenarios in advance is key to effective optimization. Moreover, the production of vast quantities of spare parts, some of which will never be used, should be explored to better assess FDR's overall environmental impact. Delivery to users and stewardship of delivered spare parts create extra costs for companies. Furthermore, there is a risk of a rebound effect, where users may request free or paid upgrades or replacements for minor cosmetic failures not affecting a product's main functions. FDR-supporting companies should carefully simulate various scenarios to gauge their environmental impact. Companies would also be wise to consult with pro-repairers to evaluate and improve such scenarios, as these individuals possess extensive repair and upgrade know-how. The use of on-demand manufacturing services and 3D printing might also help to prevent such problems.

Despite the expectation of higher product prices, participants still perceived FDR-supported products as worth paying for due to the environmental benefits they offer, reduced repair service costs, and longer product lifespans. Thus, it can be argued that FDR may lead to brand loyalty over the long term, and FDR initiatives could initially target sustainability-minded users via virtual and physical platforms. However, for sustainability-sensitive consumers to commit to FDR, companies will need to be upfront about profit motives and the ethical principles of their business model. Participants in this study agreed that repair practices prolong product lifespan and reduce waste, yet they often prefer to replace their products instead of dealing with low-quality repair services. Therefore, designing an FDR system that includes both products and services has the potential to motivate users to engage in repair activities. However, to gain users' trust and overcome negative perceptions associated with repair services, companies providing FDR support need to effectively communicate about

the repairability of their products and the efficiency of support services, especially in developing countries where consumer rights legislation and repair-focused business cases are lacking.

Limitations and Future Studies

During the course of this study, a number of limitations were identified that should be addressed in future research. Firstly, our user sample was comprised of individuals who share a similar cultural background, which may limit the generalizability of our findings. A cross-cultural study would provide additional perspectives, particularly since the negative stigma surrounding repair services may not be as strong in the Turkish context as it is in Western communities. Secondly, in the DW sessions, our attempt to include two participants from each role, both male and female, was unsuccessful, as we were unable to find participants for roles A and E, and female participants outnumbered the males. Thus, further investigations would enhance our understanding of the passive value receiver and crafter roles. Finally, while the conceptual model used in this study provides valuable insights, it should be further tested through experimental or descriptive studies to confirm its applicability in different contexts and scenarios.

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Appendix A

Appendix A. Summary table of motivations and barriers.

	Motivations and Barriers
User	• Repair experience and skills (Korsunova et al., 2023; McQueen et al., 2023; Sonego et al., 2022; Russell et al., 2023) • Environmental considerations (McQueen et al., 2023; Sonego et al., 2022) • Social norms (McQueen et al., 2023; Russell et al., 2023) • Gender (specifically for garments) (McQueen et al., 2023) • Age (specifically for garments) (McQueen et al., 2023) • Required time (Ackermann et al., 2018; Roskladka et al., 2023; Russell et al., 2023) • Trust in repair service (Fachbach et al., 2022) • Perceived cost of repair (Ackermann et al., 2018) • Societal perceptions and rhetoric around repair (Korsunova et al., 2023) • Worldview and personhood framework (Dermody et al., 2020) • Perceived obsolescence (Sonego et al., 2022) • Emotional attachment (Sonego et al., 2022) • Extended use of appliances (Sonego et al., 2022) • Personal data (Sonego et al., 2022) • Living in urban areas (Fachbach et al., 2022) • Perceived repair difficulty (Fachbach et al., 2022; Roskladka et al., 2023) • Lack of trust in repair services (Roskladka et al., 2023) • Fear of further failures (Roskladka et al., 2023) • Desire for new products or features (Roskladka et al., 2023) • Lack of awareness about repair impact and lack of repair habits (Roskladka et al., 2023) • Lack of engagement or popularization of repair (Roskladka et al., 2023) • Afraid of further damaging the product or causing injury, safety reasons, fragile materials (Ackermann et al., 2018; Roskladka et al., 2023)

Appendix A. Summary table of motivations and barriers (continued)**.**

	Motivations and Barriers
Company	• Validity and coverage of product warranty (Korsunova et al., 2023; Laitala et al., 2021; Russell et al., 2023) • Lack of clarity on how repair works (Roskladka et al., 2023) • Accessibility of spare parts and tools (Korsunova et al., 2023; Russell et al., 2023) • Lack of spare parts and tools (Hernandez et al., 2020; Roskladka et al., 2023) • Lack of technical information (Hernandez et al., 2020) • Travel time to repair service (Fachbach et al., 2022) • Unpredictable service time and cost (Lefebvre et al., 2018; McCollough, 2009; Sabbaghi et al., 2017) • Lack of provided clear repair instructions and manuals (Laitala et al., 2021; Sabbaghi et al., 2017; Roskladka et al., 2023) • Sufficiency and quality of repair service (Sonego et al., 2022; Roskladka et al., 2023) • Legislation and tax programs (Roskladka et al., 2023) • Cost of repair and diagnosis (Roskladka et al., 2023; Russell et al., 2023) • Unavailability of repair services (Roskladka et al., 2023) • Cost of replacement (Russell et al., 2023)
Product	• Ease of diagnosis (Korsunova et al., 2023) • Working with electricity (Korsunova et al., 2023) • Modularity (specifically for mobile phones) (Amend et al., 2022), • Age and condition of product (Laitala et al., 2021; Sabbaghi et al., 2017) • High-quality products (Sonego et al., 2022) • Product obsolescence (Sonego et al., 2022) • Product price (for smartphones and washing machines) (Güsser-Fachbach et al., 2023) • Access to diagnostics (Roskladka et al., 2023) • Complex and long disassembly (Roskladka et al., 2023) • Digital locks (Roskladka et al., 2023) • Unopenable products (Roskladka et al., 2023) • Impossibility of update/upgrade (Roskladka et al., 2023) • Product essentiality (Russell et al., 2023)

Appendix B

Appendix B. Survey results and user roles used in the survey.

Roles	Male	Female	Total
A (Passive Value Receiver): I do not want to deal with repair, maintenance, or upgrade of products. Even calling an authorized service for such tasks and taking the product to them is a workload that I would not prefer. I wish there was a company that would pick up the product from my home, repair/improve it, and bring it back as soon as possible.	2	6	8
B (Self-Servicer): Repairing products or replacing parts by myself is a risky action that I would not prefer. When necessary, I can try to find the right service provider to repair or upgrade the products and take the product to service. I can examine the product to check where the error is and perform simple steps such as changing the battery of the product.	1	13	14
C (Co-Repairer): If the company tells me clearly and understandably in writing, visually or verbally how to repair, replace parts, or upgrade products, I would like to do it myself. In fact, I would be very interested if the company sent me the necessary spare parts and tools to be used for repair or upgrade. It would make me feel good to cooperate with the company on this issue.	3	22	25
D (Pro-Repairer): I often try to repair, replace, or upgrade products myself first. I have the necessary tools and spare parts or can find channels to purchase them. In this type of work, I can use the spare parts or materials I have left over from other products. I know the channels where I can easily access helpful videos and documents regarding repair.	2	3	5
E (Crafter): When necessary, I always try to repair, replace, or upgrade products myself. I have the necessary tools and spare parts or can find channels to purchase them. Most of the time, I use spare parts and materials left over from other products. I even like to change products using my own creativity. If necessary, in this process, I can use spacers produced with a 3D printer or provided by manufacturers such as carpenters. I know the channels where I can easily access helpful videos and documents regarding repair.	1	1	2
Total	9	45	54

Appendix C

Interview Protocol

I'm going to describe a company that allows their users to repair, maintain, and upgrade their products.

Company A sells electronic products such as cell phones, tablets, and computers. The products of this company are designed to replace worn out or broken parts, to be easily maintained, and to be updated as needed. Products are received with some spare parts, tools, and equipment for the repair, maintenance, and upgrade processes, such as versatile and multifunctional hand tools, additional keyboard keys, SIM card trays, screws, cleaning items, etc. [The mentioned company provided part and tool examples were altered according to the described company and extended if needed]. The company also provides a large body of printed and video instructions for facilitating users' repair and maintenance processes. This means that you can maintain, repair, and upgrade your product yourself at home. The company also offers call center, repair, and maintenance services, if needed. [Details about the company were explained to the participant if needed during the interview.]

[The questions below are designed to initiate the discussion. Additional questions have been used to elicit deeper data from the participants depending on the direction and flow of the interview.]

  1) Did you engage in repair activities before?

      a) How did you engage? When did it happen?

      b) Can you tell us about your worst / best experience?

      c) Have you experienced something similar to what I described?

  2) How would you describe the company that designs such repairable and upgradeable products? What kind of company is it?

  3) Would you prefer this company's products? Why or why not?

      a) In which product categories do you prefer such products? Why?

  4) What do you think about the price of such a product?

  [Same procedure is repeated for companies B, C, and D]

- Company B sells household electrical appliances such as vacuum cleaners, irons, mixers, etc.
- Company C sells fashion products such as clothes, accessories, bags, and shoes.
- Company D sells furniture products such as tables, chairs, and convertible sofas.

Appendix D

FDR Experience Prototype–Desktop Walkthrough

Preparation

Scope and Prototyping Questions

The prepared prototype aims to explore how the FDR experience is perceived by users in four different product categories, and how the individuals, products, and services involved in this process affect the overall experience. The prototype focuses on the facilitated self-repair experience of users in a setting that includes all possible actors and services available in the context of Istanbul. Due to the representative and exploratory nature of the DW workshops, we aimed to use the tool to understand the participants' perception of FDR in relation to other available actors and services, as well as to identify potential improvements to the FDR experience. For the prototype, four hypothetical companies were revisited, which were used during the interview process and were defined by adapting the value propositions of existing cases such as Fairphone, Nudie Jeans, Patagonia, and Orangebox, all of which offer product service systems akin to the FDR experience under consideration. Thus, a mobile phone, an outdoor jacket, and an office chair were selected as objects to be used in the desktop walkthrough. Additionally, from the small home appliances category, a kettle was chosen as it was studied in prior research focusing on self-repair.

Two desktop walkthrough sessions were planned, in which 5 people would participate in each round and comment on their experience with 4 products.

Workspace, Materials, Actors

Products: Mobile Phone / Kettle / Jacket / Office Chair

Company info: The company places a special emphasis on sustainability and highlights product repairability and upgradeability with extensive user-friendly services that encourage consumers to use their products for a longer period of time.

Actors (Repair Options), Their Main Services and Touch Points

MC: Manufacturer Company

Istanbul Main Branch Building: Product sales, frequently used spare parts and tools sales

After-sale service department: Repairing and upgrading products

Website: Online repair instruction manuals as documents, video instructions, spare parts, and tool sales

Social media / Forum: Facilitate user interactions

Mobile app: Repair and upgrade visual instructions, AI assistant, chat with representatives

Call center: Information about products and services

Pickup and on-site repair service: Delivering required spare parts and tools to consumers

The product comes with fundamental repair and disassembly instructions, main utility tools, and spare parts.

Authorized repair shop (ARS): uses only original spare parts and pre-defined repair processes

Shop: Repair and upgrade service, frequently used spare parts and tools sales

Call center: Information about repair processes, price, and current product status

Independent repair service shop (IRS): uses original and aftermarket spare parts and various repair processes

Shop: Repair and upgrade service, frequently used spare parts and tools sale

Call center: Information about repair processes, price, and current product status

Website: General information about the company

ERS: Exclusive independent repair service shop

Website: General info, service demand, checking service process

Call center: Service demand, information about repair processes, price, and current product status

On-site service and parcel pickup: Onsite same day repair, parcel pickup and delivery

RC: Repair café

Café: A meeting and learning space, tools and spare parts available, advanced and novice repairers and fixers (event happens only once a month, no reservation required)

Website: Info about the café and events

Social media: Info about the café, events, and participant interaction

SPM: Spare Part Market

Shop: Sale of all spare parts from many brands, tools, and provide general technical info

iFixit: Social Platform

Website: Learning, sharing, and collaborating to repair various products, their specifications, and repairability ranks. Online sale of spare parts, tools, and repair kits. An online community to learn, discuss, and share repair stories and instructions.

Appendix D1. Elements of the map produced for the DW sessions.

Spaces	Objects and vehicles	Characters
• Home • School • Workplace • Company • Repair Shop of ARS/IRS /ERS OEM shop • Repair café • Park • Bus stops / metro stations	• Mobile phone • Kettle • Jacket • Office chair • PC • A set of special repair tools, spare parts, and instructions were included with products (Different set for each product category: Mobile phone, Kettle, Jacket, Office Chair) • Other generic tools and equipment at home • Onsite Repair Service vehicle • Bus • Metro	• User • Family member(s) • Friend(s) • Company worker(s) • Repair service worker(s)

Journey Drafts

For the DW session, iFixit instructions were used to identify an easy and a difficult repair process for each product.

Initial scenario: You are a student, attending lectures three days per week and you intern at a company once a week; you live with friends or at home with your family. You have your own room in the house. You are at home preparing to go to school and you realize that a product you bought from the company has a failure. What would you do?

Appendix D2.

Journey 1 Mobile phone	Journey 2 Kettle	Journey 3 Jacket	Journey 4 Furniture
J1A) The SIM card is not functioning sometimes and now it is not recognized by the phone [1]. J1B) Rear camera of your phone is not functioning [2].	J2A) The switch of the kettle is too loose, sometimes not functioning [3]. J2B) You have plugged the kettle in, but it does not heat, nor is the light on [4].	J3A) There is a crack in the arm of your leather jacket [5]. J3B) The main zipper is not working [6].	J4A) The wheel of the chair is broken [7]. J4B) The chair is not lifting up anymore [8].

Note:
[1] https://www.ifixit.com/Guide/Samsung+Galaxy+S20+Plus+SIM-MicroSD+Card+Tray+Replacement/136339
[2] https://www.ifixit.com/Guide/Samsung+Galaxy+S20+Plus+Rear-Facing+Camera+Module+Replacement/136352
[3] https://www.ifixit.com/Guide/Tea+Kettle+Switch+Replacement/78703
[4] https://www.ifixit.com/Guide/Oster+Digital+Electric+Kettle+BVST-EK5967+Thermal+Cutoff+Fuse+Replacement/47470
[5] https://www.ifixit.com/Guide/How+to+Fix+A+Cracked+Leather+Jacket/158104
[6] https://www.ifixit.com/Guide/Installing+A+Main+Zipper+In+Your+Patagonia+Down+Jacket/19432
[7] https://www.ifixit.com/Guide/How+to+Replace+the+Wheels+on+an+Office+Chair/140037
[8] https://www.ifixit.com/Guide/Realspace+EC600+Office+Chair+Lift+Cylinder+Replacement/138597

Appendix D3. Desktop walkthrough, execution plan

Desktop Walkthrough Session 1 (Participant W1, W2, W3, W4, W5) 90 min				Desktop Walkthrough Session 2 (Participant W6, W7, W8, W9, W10) 90 min			
J1E, J1D	J2E, J2D	J3E, J3D	J4E, J4D	J1E, J1D	J2E, J2D	J3E, J3D	J4E, J4D
Participants: N, O, P, R, S				Participants: T, U, V, Y, Z			

Research

At the start of each session, the roles that participants indicated in the survey answers were repeated and confirmed, and the landscape of the DW board was introduced to the participants. All actors, as well as each of their locations in the city, products, services, and touchpoints, were introduced to the participants. Additionally, an individual space representing each participant's room was assigned to them.

Following the introduction of the board, DW tools such as colored pens, post-it notes, play-dough, Legos, and figurines were given to the participants to encourage them to think, discuss, and design during the session. Participants were informed that they would be given free reign during the repair journeys and could modify them and share their thoughts as much as they desired.

Following a brief introduction describing the hypothetical company as explained above, each participant was given the cards representing the product under consideration as well as its repair and upgrade kit, including two special tools and a set of repair instructions, which were presumed to have been included with the product at the time of its original purchase. Later, the repair tasks (initially the easy one and then the difficult one) were shared with the participants, who were asked to act and reflect on their experience.

Throughout the process, additional questions were posed to the participants to obtain a deeper understanding and encourage discussion. Additionally, we intentionally steered the participants towards discussions about several topics derived from an analysis of the semi-structured interviews. These included participants' preferred way of dealing with the tasks for each product, the number of spare parts they expected to receive when purchasing the product, how they would handle product issues within and beyond warranty periods, perspectives about the company offering FDR, and overall impressions of the FDR experience in terms of time efficiency.

Video and audio recordings were augmented by notes taken by one of the researchers during the desktop sessions.

Appendix E

Appendix E. Codes, lower-order categories, and higher-order categories.

Codes*	N**	Lower-order Categories	Higher-order Categories
with all the supportive materials, would like to try repairing; prefer inclusive repair service instead of FDR; would try to repair; capable of such things; may ruin while fixing; proficiency-related interest in product components; technological products are a nightmare for me; authority; self-confidence after repair; feel encouraged; need for end-user perspective	18	Interest and Capability Enhancement	Empowerment Boosting Mechanism
have time to repair; prefer to spend my free time; repair as a family activity; ask help from my family and friends	9	Socializing Activity	
sustainability is the most important criteria; contribution to protecting the environment; would promote and share in social media	7	Symbolic Meaning	
time-saving; transferring products to the professional service takes time; professional repair service causes a long waiting time; can fix and continue using without waiting	13	Time-efficiency	
gives a sense of accomplishment; makes you feel successful; enjoy being able to do by myself; pride	14	Sense of accomplishment	Sense of Empowerment
stand on one's own legs; prefer to do my own tasks; not requiring others to help makes me feel good; as a woman, it is good to do independently; hesitation to interact with repair technicians at home	8	Sense of Independence	
pleasant experience; reviving a product makes happy; a sustainable system makes me feel good	10	Pleasure	
would have a good time; enjoyable; new hobby	11	Joy	
environmentally friendly; less waste; sensitive to nature; believes in sustainability	8	Environmentally friendly	User-Based Company Reputation
beyond the times; innovative; forward-thinking; fore sawing	5	Innovative	
creative; trying new things; enriches my creativity	4	Creative	
attractive; curiosity arousing; distinctive; there is no such firm	5	Distinctive	
budget-friendly; its ok to pay more; can use the product longer, so worth paying more; willing to pay more for upgradeability; provided materials make it worth paying more	16	Justifies higher prices	
powerful; comprehensive company; strong; self-reliant; widespread network for products and spare parts	5	Powerful	
good customer relationship; responding consumer needs; considers user benefits; cares users; problem solver; customer-oriented	15	Customer-oriented	
standing behind its products; would trust in this company; produces high-quality products; transparent to let users see inside of products; supportive; suspicion of low-quality products (why do they give this repair kit?)	13+3 (negative)	Reliability	
in products made to last; exposed to changing trends (fashion); wish my personal electronics could be for lifelong; use for longer periods	5	Perceived lifespan of product	Product Category-Driven Evaluations
mobile phones are fragile objects, FDR would help, fashion products are not robust	3	Perceived fragility of product	
in favour of repair due to product price; better to repair expensive products than replace	4	Price of product	
(FDR) good for frequently used products; lifesaving in emergencies; don't want to wait because frequently used and needed; mobile phones are used frequently and fail a lot thus would prefer FDR	9	Perceived frequent use of the product	
less essential; won't repair; not emergent; use without repairing	6	Perceived essentiality of the function/product	
used a lot and a long time; heavy used and thus wears out; furniture are heavily used products and require maintenance	3	Perceived heavy use of product	
not practical in fashion products; electronic products are more prone to upgrade; good for regular maintenance requiring products; fashion changing-fast	6	Perceived appropriateness of repair and upgrade	
needs expertise for repair (electronic); can break them while trying to fix; risky and needs design knowledge (fashion); they are technical objects; can't fix electronics even with supportive materials; risky in some categories	16	Perceived need for expertise	
want to safeguard my private data; afraid of giving a product with personal data; original parts can be stolen	5	Data and product security	

Note: * Examples of codes emerging from raw data are presented
    **Number of participants