OPEN DESIGN FOR PRODUCT/PART LONGEVITY: RESEARCH THROUGH CO-DESIGNING WITH A FOCUS ON SMALL KITCHEN APPLIANCES

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ABSTRACT

OPEN DESIGN FOR PRODUCT/PART LONGEVITY: RESEARCH THROUGH CO-DESIGNING WITH A FOCUS ON SMALL KITCHEN APPLIANCES

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The rise in the open-source hardware practices, and Do-It-Yourself and Maker movements through newly-developing internet technologies (e.g. Wikis and user-generated content), and the dissemination of end-user focused digital production technologies (e.g. 3D printers, laser cutters, etc.) helped design practice evolve towards a more inclusive process. *Open Design* approach presents a continuous process of co-designing that is open to everyone, with no limitations on time, space and kind of contribution. In literature, this approach is mentioned to reveal opportunities for sustainability concerns such as repair, reuse and upgrading of parts and products, due to its transparent process of sharing design data. However, as a newly-developing approach, the practical opportunities and the implications of it for sustainability have not been questioned beyond its observable possibilities.

The purpose of this PhD study is to shed light on the question of adopting open design approach for sustainability concerns of product/part longevity, personalization and part reuse, and to explore the implications of open design for these concerns to transform already established product types (i.e. small kitchen appliances). For this purpose, *research through co-designing* methodology was developed and applied through the utilization of two different design workshops on practices shaped around small kitchen appliances. The study revealed *sustainable design considerations* for idea-generation, *open part properties* that respond to these considerations, *strategies of adopting and iterating* open design solutions and their implications for product/part longevity, personalization and reuse.

Keywords: open design, design for sustainability, research through designing, small kitchen appliances, sustainable design considerations

ÖZ

ÜRÜN/PARÇA ÖMRÜNÜN UZATILMASI İÇİN AÇIK TASARIM: KÜÇÜK MUTFAK ALETLERİNE ODAKLANARAK BİRLİKTE TASARIM YOLUYLA ARAŞTIRMA

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Açık kaynaklı donanım uygulamaları ile Kendin-Yap ve Maker akımlarının yeni geliştirilen internet teknolojileri (örn. Wiki'ler ve kullanıcı tarafından oluşturulan içerik) aracılığıyla gelişmesi ve son kullanıcı odaklı dijital üretim teknolojilerinin (örn. 3B yazıcılar, lazer kesiciler, vb.) yaygınlaşması, tasarım pratiğinin daha kapsayıcı bir şekilde gelişmesine yardımcı oldu. *Açık Tasarım* yaklaşımı, zaman, mekan ve katkının türü konularında herhangi bir kısıtlama olmadan, herkesin katılımına açık, devamlı bir birlikte tasarım süreci sunar. Literatürde bu yaklaşımın, tasarım verilerinin şeffaf bir şekilde paylaşılması sayesinde, parça ve ürünlerin onarımı, yeniden kullanımı ve yenilenmesi gibi sürdürülebilirlik kaygıları için çeşitli olanaklar sunduğundan bahsedilir. Bununla birlikte, yeni geliştirilen bir yaklaşım olarak, sürdürülebilirlik için bu yaklaşımın pratik imkanları ve kısıtları, gözlemlenebilir olasılıklarının ötesinde sorgulanmamıştır.

Bu doktora çalışmasının amacı, ürün/parça ömrünün uzatılması, kişiselleştirme ve parçaların yeniden kullanımı için açık tasarım yaklaşımının benimsenmesi ve halihazırda şekillenmiş ürün türlerini (küçük mutfak aletleri) dönüştürmek konusunda,

açık tasarımın etkilerinin anlaşılması konularına ışık tutmaktır. Bu amaçla, birlikte tasarım yoluyla araştırma yöntemi geliştirilmiş ve küçük mutfak aletlerinin etrafında şekillendirilen mutfak pratikleriyle ilgili iki farklı tasarım çalıştayı kullanılarak uygulanmıştır. Çalışma, fikir geliştirme için *sürdürülebilir tasarım ölçütleri*, bu ölçütlere cevap veren *açık parça özellikleri*, açık tasarım çözümlerini *benimseme ve değiştirme stratejileri* ve bu stratejilerin ürün/parça ömrünün uzatılması, kişiselleştirme ve yeniden kullanım konularına etkilerini ortaya koyar.

Anahtar Kelimeler: açık tasarım, sürdürülebilirlik için tasarım, tasarım yoluyla araştırma, küçük mutfak aletleri, sürdürülebilir tasarım ölçütleri

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CHAPTER 1

INTRODUCTION

The practice of design is in a state of transitioning under the heading of democratization. Involving the people who are affected by the design decisions in the design process itself through the participatory design approach (Ehn, 2008), followed by regarding the users as equal partners of the design process in co-design approach (Fuad-Luke, 2009) have blurred the lines separating the roles of users, designers and producers. This has resulted in perceiving the users as active shareholders in making design decisions and production, rather than passive providers of user-related information (Stappers *et al.*, 2011; von Hippel, 2006).

Through an historical perspective, enabling the user to reach design data and empowering them to take part in design and production phases date back to *Do-It-Yourself* movement emerged in 1970s (Shove *et al.*, 2007). Visible in furniture projects like *Nomadic Furniture* (Hennesey & Papanek, 1973) and *Autoprogettazione?* (Mari, 1974: 2014), this movement advocates openly sharing of design data for solutions the users can produce themselves with accessible production techniques. Today, *Do-It-Yourself* and *Maker* movements enable the development, dissemination and production of a broader range of design solutions by users, designers and small-scale producers, with the help of developing internet technologies (e.g. Wikis and user-generated content) and end-user digital fabrication technologies (e.g. 3D printers, laser cutters, etc.).

Open design, although it presents similarities with the above-mentioned approaches, gets its name from the *open-source model* in software business. Online platforms that are open to any kind of contribution from anyone (e.g. Wikipedia, iFixit, Instructables, etc.) are examples which blur the lines between content generators and users, and which present the potentials of creating and sharing open-source knowledge (Maurer & Scotchmer, 2006). Adopting this open-source model to create physical objects and including different shareholders in the whole stages of the design process and decision making is a new topic in literature (van Abel *et al.*, 2011; Raasch *et al.*, 2009). In this light, open design depicts a process in which design data is shared without any limitations, and can be used or altered anyway by anyone (Tooze *et al.*, 2014). This process can be regarded as a co-creation process without any limitations on time, place, kind and size of the contribution, regardless of the capabilities or expertise of any contributor.

The potentials of open design on sustainability are mentioned in literature. Open part and product designs can be altered and personalized for different people, can be repaired when they are broken and can be developed further, thanks to the possibility of intervention and openly available knowledge (Thackara, 2011). Sharing open design solutions and knowledge about them can initiate constitution, development and especially dissemination of alternative, sustainable lifestyles and economies (Manzini, 2015; Thackara, 2011). On the other hand, open design approach can be assimilated swiftly, and become a new product typology that conforms mass-production and mass-consumption (Thackara, 2011). Hence, it is important to explore and make visible the potentials of open design for sustainability, both in theory and in practice.

The problem of discarding or replacing functioning products and parts due to aesthetical or technical reasons is frequently mentioned in design for sustainability literature (Walker, 2011; Cooper, 2010; Doğan, 2007; Chapman, 2005; Verbeek & Kockelkoren, 1998). Inability to access post-use services (i.e. repair, part replacement, part reuse, upgrading) results in replacing whole products even when only one part of them is broken and the others are still functioning (Walker, 2011; Cooper, 2010; Doğan, 2007). Even if the users could access post-use services, the bond between users and products needs to be strengthened and users need to prefer post-use services instead of replacement. Hence, design solutions that respond to changing needs and preferences of different users need to be developed through the active participation of users in the design process, for personalization (Mugge *et al.*, 2009) and emotional durability (Chapman, 2005). This PhD study concerns itself with product/part longevity aspect of sustainability through an open design approach. Open design solutions can be developed to facilitate reuse of open parts and to adapt to people's needs and preferences, which in turn elongates the lifecycles of parts.

1.1. Significance of the Topic

The widespread application of open design is currently focused on the understanding of users' inclinations towards new types of products through approaches like crowdfunding (e.g. Kickstarter, Indiegogo) and crowd-speaking (e.g. Phonebloks and its continuation as Project Ara), on the development of alternative ideas and widening the solution areas for a design problem through crowdsourcing, or co-creation models that aim to include people (professionals and non-professionals) in the very early steps of idea-generation (e.g. OpenIDEO, Quirky). There are also more democratizing attempts, like Design for Download by Droog Design, which aim to share digital design data to enable the reproduction of parts and products on the different parts of the world. Although such examples excite me as a designer and a design researcher, two different problems come to fore:

> 1. Established product types and practices around them: Open design has the potential to transform the way we produce and use products, as well as transform the whole meaning of what a product is. For example, it can de-construct an already established product category (e.g. small household appliances) and behaviors shaped around them (e.g. tea making, toasting, chopping, mixing, etc.), and offer alternative, sustainable models of use through putting forward a new breed of adaptable, sustainable objects. In this study, the focus is the kitchen practices shaped around small kitchen appliances, as they already have established features and properties, and they are widely used every day, often replaced when broken.
>
> 2. Reusing produced open parts: Although open design process enables co-creating and sharing design related data with various contributors, practical examples of it do not tackle with the reuse of an open part in different part assemblages. The openness of design processes and solutions is gauged with

the possibilities it creates on design and production. However, given the right focus, open design can yield solutions for part longevity through personalization and part reuse.

The above-mentioned problems are the main reasons why I undertook this PhD study, to explore the potentials of open design processes and solutions for product/part longevity, through de-constructing already established product categories and offering alternative open solutions that enable personalization and part reuse.

1.2. Aim, Goal and Research Questions

This study aims to find out how open design approach can respond to sustainable design concerns of product/part longevity, design for post-use and personalization in established product categories, through exploring the possibilities it creates and the limitations it presents for small kitchen appliances and kitchen practices.

The goal of this study is (1) to analyze existing concerns and explorations to propose an initial framework for revealing open, sustainable design considerations that challenge and transform an established product type (i.e. small kitchen appliances), (2) to develop open, sustainable design considerations to be utilized with this model, (3) to refine these considerations by finding out their design implications in a conceptual design process, (4) to find out open part properties that can respond to these considerations and to understand how these properties are useful for the sustainability concerns of the study through the design explorations developed by participants of the study, which showcases the opportunities and limitations of open design for product/part longevity, design for post-use and personalization. The outcomes of this study as a whole can be used by people who adopt open design approach for developing open, sustainable solutions for kitchen practices, or the methodology of the thesis can be used by people who want to create open, sustainable design solutions that challenge and transform established product categories.

The study asks these questions to reach its goals:

1. What are the implications of open design to respond to the sustainable design concerns of this study [i.e. product/part longevity through post-use services (i.e. repair, part replacement, part reuse, upgrading) and personalization]?

What are the opportunities and limitations of open design approach for these sustainability concerns?

2. What are the design considerations that can lead people who contribute to the open design process to design open, sustainable solutions for kitchen practices?
3. What are the properties of open part designs that respond to these design considerations and help achieve the sustainable design concerns of the study? How do these open part properties respond to the design considerations?
4. How can the design considerations and the responding open part properties be developed for a co-creation process like open design?

1.3. Structure of the Thesis

This thesis starts with a survey of literature related to open design and sustainable design approaches with the purpose of locating this study among many others. Later in the *Methodology* chapter, a new approach on research through designing is introduced, and its application within this study is outlined in relation to the research questions. The following three chapters build upon each other to present *open design processes*, *design considerations* and *open part properties* to achieve product/part longevity, part reuse and personalization, with a focus on kitchen practices shaped around small kitchen appliances. The main contributions of the thesis and answers to research questions are presented in the conclusion chapter.

CHAPTER 2

OPEN DESIGN AND DESIGN FOR SUSTAINABILITY

Sustainability literature has evolved considerably since the term came along in 1987 (WCED, 2007). Currently discussed commonly in literature from various perspectives – e.g. economic (Korten, 2009; Daly, 1991), social (Foster *et al*., 2011; Zizek, 2009), and environmental (Lynas, 2009; Lovelock, 2007) – and supported extensively by various NGO reports (e.g. UNDP, 2013, Global Footprint Network, 2012), awareness for the need of sustainability is established widely. Many corporations have developed policies to transform their practices in a seemingly more sustainable fashion (e.g. “Conscious” campaign by H&M, “Office 360 to NPOs” by Microsoft). As mentioned in the short essay of Treanor (2005) bluntly, the sustainability practices visible in businesses do not concern themselves with sustaining environmental stewardship, economic stability or social equity, but rather focused on the survival of the currently widespread modes of production and consumption. That is most visible in LCA-based manufacturing innovations, like Cradle-to-Cradle (McDonough & Braungart, 2002) or even its current spin-off: Circular Economy (Ellen MacArthur Foundation, n.d.). Aiming at the slightly altering of the current modes of production and consumption, these approaches reduce the concept of sustainability to a quest for a mere time-extension for business-as-usual through adopting a train of thought on efficiency and sufficiency. The quest for sustainability requires, however, a detachment from the ways we conceive our material culture, in which production, use and post-use of objects happen sequentially and these steps of product life-cycle are addressed as separate steps.

This doctoral research adopts an understanding of sustainability that takes the implications of local and individual needs, their transformations according to context, and local and individual skills' effects on these, within the area of product design. Therefore, it is critical to comprehend the relations between local and individual traits, and environmental, social and economic aspects of sustainability. There are various approaches in literature that share similar concerns regarding sustainable design. These approaches explore various possibilities in designing of objects regarding the integration of different scales of production (i.e. centralized, regional, local, and individual scales) (Doğan, 2007), ways of enabling post-use processes (i.e. maintaining, repairing, upgrading and reusing) (Walker, 2006; Doğan, 2007; Marchand, 2008), changing local and individual needs and preferences (Walker, 2006, 2011; Doğan, 2007; Van Nes, 2010), product attachment and meaning (Van Nes, 2010; Chapman, 2005), resource consumption during product use (Bhamra *et al.,* 2011; Tang, 2010; Lilley, 2009), facilitating social change and well-being through social innovation (Manzini, 2015; Manzini & Rizzo, 2011) and co-creating with people to achieve social, institutional, environmental and economic change (Fuad-Luke, 2009). As a result of these approaches, it is possible to state criteria for sustainable design with respect to sustainable production and consumption, through design considerations they present, which are interwoven with each other.

The purpose of this literature review is to understand not only what design can do in the pursuit of sustainability, but also the implications of the recently rising paradigm of open-source in product design, which challenges the prevalent modes of production and consumption through open-to-all design, production and post-use processes (Stikker, 2011). In this literature review, Open Design is presented as an alternative co-creation process not with a purpose of reaching a finalized design solution of local consensus, but with a purpose of many iterations of an adaptable, initial design solution that can respond to the needs, wants and desires of a multitude. Open Design represents limitation-free creating and sharing of design knowledge, with global solutions attuned to local and individual needs and preferences that consist of reachable, repairable and interchangeable open parts solutions.

This literature review starts with presenting various approaches to sustainable design and how they respond to sustainability, continues with presenting open design, its unique position among other participatory approaches and its relation to sustainability.

2.1. Design for Sustainability

As advocated by many designers and design researchers (Manzini, 2015; Walker, 2011, 2006; Doğan & Walker, 2008; Fuad-Luke, 2010; Van Nes, 2010), the practice of design needs to challenge the way we have created our current material culture and to develop alternative relations of creating, using and keep-using artefacts. The challenges are towards centralized mass-manufacturing processes, products that have become complex and closed to respond everyone's needs and preferences, distributing these products everywhere on the planet, purchasing products of globally-set features that may or may not respond individuals due to the inability to adapt/change/design these closed products to match our needs and preferences, not being able to understand how the way we use affects our environment or our social lives, inability to repair them when they are broken or upgrade them when our needs and preferences change, finally disposing of them although they (or some parts of them) are still functional and usable. This many-faceted challenge against our current material culture brought forward many approaches to design for localization, personalization, co-creation, sustainable behavior, post-use and further. In this section, through design solution examples with expanding focuses, I will present the opportunities and challenges of design for sustainability.

2.1.1. Buying Anew vs. Repair, Upgrading, Reuse

Until the 20th century, products were intended for long-term usage and their quality was judged to according to how long they will last (Cooper, 2005). However, due to the advancements in mass-production, prices getting lower and lower, and the ability to reach any kind of products easily, resulted in what Papanek (1971) called a *throw-away culture*. Low-quality materials, planned obsolescence, disposable products, etc. decreased the production costs – and consumer prices – and led towards mass-consumption (Cooper, 2005). Today, most of the products cannot be repaired due to their design resulting in unreachable parts (Norman, 1998), or it is simply not cost-effective to repair them (Cooper, 2010). On the other hand, the rapid development of technology (Verbeek & Kockelkoren, 1998) and marketing-led changes in aesthetic preferences (Chapman, 2005) result in users' reluctance to get their products repaired. Today, what defines our consumption practices is not taking care of what we already own, but a tendency to buy anew.

The environmental impacts of such *throw-away culture* were challenged by alternative economic models, like Circular Economy (Ellen MacArthur Foundation, 2012). Circular Economy aims to transition towards a restorative, circular model (Ellen MacArthur Foundation, 2012), which builds upon other systems-thinking approaches, like biology-inspired the Life's Principles (Biomimicry.net, n.d.) and closed-loop production model Cradle-to-Cradle (McDonough & Braungart, 2002).

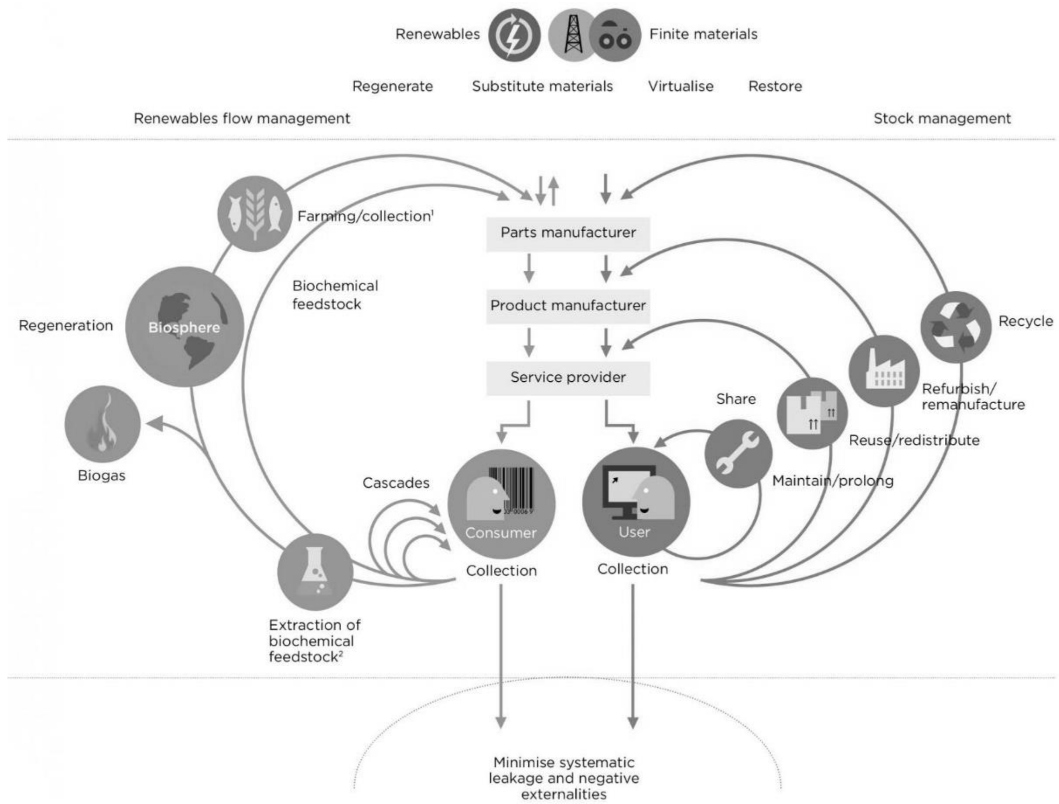

Figure 1. Circular Economy Diagram (Adapted from Ellen MacArthur Foundation, n.d.).

As can be seen in Figure 1, Circular Economy Diagram defines responsible stakeholders for maintenance and product longevity (i.e. user), the reuse of products and their redistribution (i.e. service provider), refurbishing and remanufacturing (i.e. product manufacturer) and recycling (i.e. parts manufacturer). The purpose of the diagram is to promote a new economic model developed on top of the existing one, which considers the consumer/user as the passive participant in all this system, yet responsible for sending back their products to responsible stakeholders. Design for sustainability, however, does not concern itself only with what users should do (i.e. collecting and sending them back to responsible stakeholders) but also with the resolution to actually do it, or involve in all these loops (i.e. maintain, reuse, refurbish, recycle) themselves (i.e. individually) or with what is within their reach (i.e. local repair services and craftsmen).

Figure 2. Family of drinking glasses with red dots (right) and family of cutlery pieces with red handles (left) by Anne Marchand. (reproduced from Marchand, 2008).

A challenge towards the conventional ways of designing and producing, as well as the notions of aesthetics and resulting obsolescence, design for post-use criticizes the lack – or unreachability – of post-use processes – i.e. repair, refurbishment, redistribution, retrieval of materials – in most consumer products (Walker, 2006). In the literature, these notions are challenged through design explorations reconciling polarities such as old and new, valued and undervalued, craft and mass-produced, diversity and unity (Walker, 2011; Marchand & Walker, 2007). Some of these explorations attend to the concerns of sustainability by enabling post-use services at the local scale (Walker, 2006) and others, by allowing transitioning from technologically and aesthetically obsolete products to useful, aesthetically pleasing objects (Marchand & Walker, 2007). These explorations are generally focused more on the "enduring notions of human meaning and spiritual understanding", rather than "prosaic functionality" (Walker, 2011, p.3). Through enabling repair and/or re-use of parts and products, this approach tends to elongate the lifespans of products and parts. Figure 2 presents such an exploration by Anne Marchand, in which seemingly disparate products are modified with red dots or red handles to re-contextualize them and create a unity among them: a family of objects. This results in the reuse of each glass or piece of cutlery, elongating their lifespan.

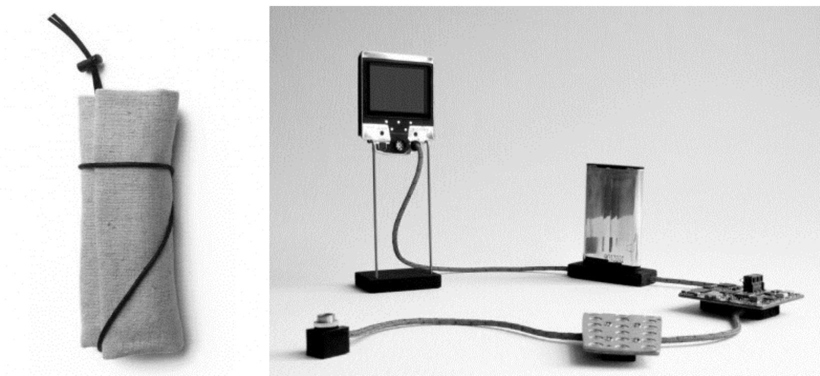

Figure 3. Pouch Phone by Stuart Walker (reproduced by Walker, 2010).

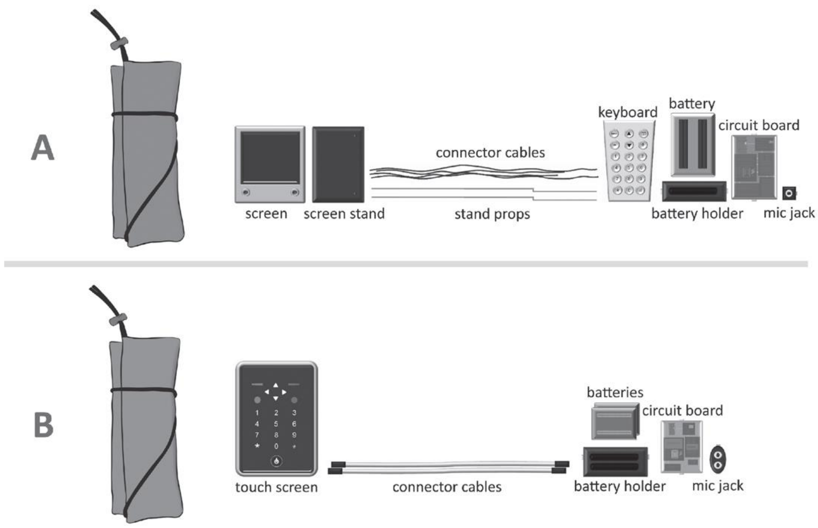

Figure 4. The illustration of the potential in incremental upgrading of the pouch phone concept by Stuart Walker (reproduced from Walker, 2010).

Another example of rethinking objects for repair and upgrading is the Pouch Phone by Stuart Walker (Figure 3). This design concept presents a modular and open structure, in which all parts are visible and they are attached and detached for every use. When the parts are detached, they are kept in a fabric pouch, which can enlarge to house additional parts if there is a need for an additional feature or a part is replaced by another, bigger part (Walker, 2010). Figure 4 shows how the pouch phone can house various parts according to different needs and preferences, and how it can be upgraded by only replacing the necessary parts. Through this incremental upgrading, electronic waste is reduced – as user only discards the replaced part, not the whole phone – and each part is used as long as they are kept functioning (Walker, 2011).

These examples are presented to show the alternative ways of perceiving products and elongating their lifespans through the possibilities created through reflexive design practice. Instead of rearranging existing stakeholders, design for sustainability imagines the question of how objects should be, in alternative, possible economic systems, to minimize their environmental and social impacts.

2.1.2. Centralized (Mass-) Production vs. Localization

Locally produced products do not rely on global distribution networks, and they support local economies by supporting local producers (Shedroff, 2009). However, localization has further potentials on diversity, responding to local needs and preferences, providing post-use services on local level. By recognizing the benefits of uniform, mass-produced parts and the benefits of local and regional production with respect to cultural diversity and post-use services, Integrated Scales of Design and Production for Sustainability (ISDPS) aims to raise the effectiveness of localization in design, production and post-use services by integrating it with mass-production (Doğan, 2007). The term localization refers to local craftsmanship and batch-scale production with design solutions for diverse user tastes and preferences, and locally available post-use services (i.e. repair, reuse, and recovery). The approach proposes a blurring of the lines between the scales of design and production (local craftsmanship, regional batch production and centralized mass-production) to allow variety and divergence, adaptability and flexibility (Doğan & Walker, 2008). The approach aims to develop design solutions that empower the local knowledge and skills, while it does not ignore the technological benefits of mass-production altogether.

Figure 5 shows how similar designs using same mass-produced parts (i.e. electrical parts) can be developed in different localities. The one on the right is produced with glass jar and stockings, while the one on the left is produced with glass jar, hand-woven fabric and ceramic lid. Different localities' access to different production techniques and materials show how these products reflect the cultural diversity among them, while supporting local economies. Since the final assembly is done at the local scale, post-use services (i.e. repair, upgrading and reuse) are also accessible to users.

Figure 5. Black Lamps by Çağla Doğan - (left) made out of glass jar, woman's stockings, electrical parts, and (right) made out of glass jar, hand-woven fabric, ceramic lid and electrical parts (reproduced from Doğan, 2007).

2.1.3. Mass-produced vs. Personalization

One of the most effective notions to encourage people to participate in the design process is personalization. Design for personalization can strengthen the relationship between the user and the product, and therefore can prevent or delay the disposal of products, and elongate the product life-span (Fuad-Luke, 2010; Van Nes, 2010; Mugge *et al.*, 2009; Chapman, 2005). The personalization of products informs people about the parts and their assembly by encouraging their participation into design process, and can enable people to understand the post-use processes (maintenance, repair and upgrading) to be followed for those products. Such awareness can also enable people to intervene with the design and production of products to fit their individual needs and preferences on functionality and their own aesthetical concerns (Doğan & Walker, 2008). The level of intervention can vary greatly according to the product life-cycle phase the user is involved – i.e. idea-generation, design detailing, production, assembly, etc. There are many perspectives on what personalization refers to: from mass-customization (Kaygın Sel, 2013), in which pre-designed, mass-produced alternatives are presented to the user to select and combine, to half-way design (Fuad-Luke, 2009), in which products are designed up to a certain level to be completed by direct user involvement. Mass-customization will be explained later in *Section 2.2.4. Tools, Methods and Approaches for Open Design Processes*, as it has evolved into something more open to user participation with the recent developments in technology (e.g. Web 2.0 and user-generated content). However, it should be noted that the kind of personalization adopted throughout his study is rather critical on mass-customization, as it does not offer any alternative means of production and consumption. Direct user involvement is of key importance to personalization from the perspective of design for sustainability, as through such an involvement in design, production and post-use, the relationship between the user and the product can be strengthened (Ozan & Doğan, 2014).

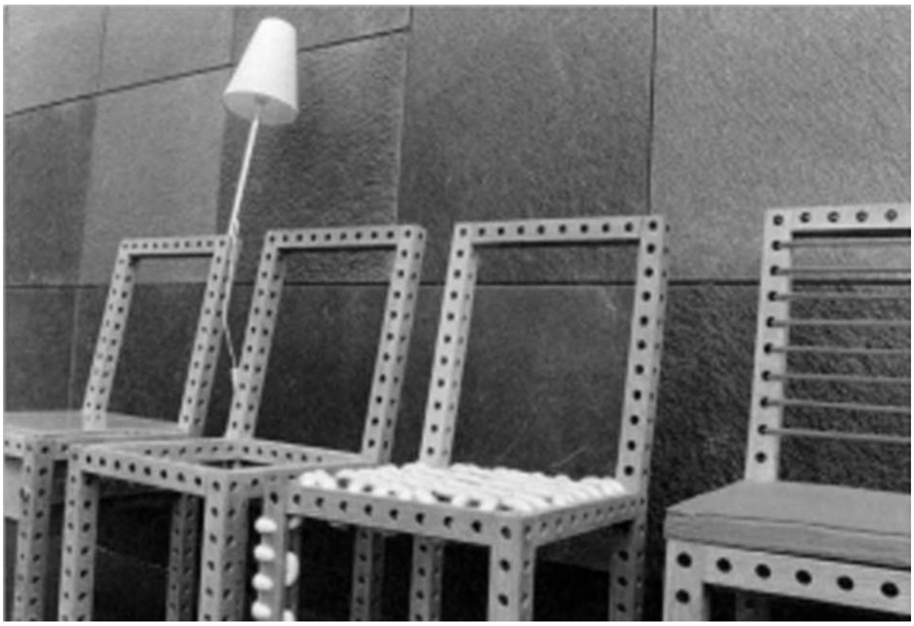

Figure 6. An Affair with a Chair by Natalie Schaap (adapted from Fuad-Luke, 2009).

Figure 6 shows an example of half-way design developed by Natalie Schaap. A chair frame built out of wooden parts with consecutive holes is acquired by users to build the kind of chair they want out of the materials that are available. On the left end side, the frame is finalized with a transparent seating surface and a reading light attached to the backrest. In the middle, the seat is finalized with a weaving of thick, white thread that flows down to one foot. On the right end side, the seat is finalized with an orange cushion and the backrest is finalized with horizontal, consecutive orange threads. All these examples show how half-way design can involve users in the design and production of the final product to reflect their needs and preferences. Furthermore, the added elements can be replaced by other elements to upgrade the product if the user decides to, without discarding the chair frame.

2.1.4. Consuming vs. Sustainable Behavior

The socio-ecological impacts of products are not only related to the way they are produced and acquired by people, but also the ways they are used in everyday life. The detrimental effects of everyday use of products are challenged through design for sustainable behavior approach (Lilley *et al.*, 2005). This approach particularly aims to develop strategies for fostering transition towards sustainable behavior, through the design of products and services (Lockton, 2013; Lidman & Renström, 2011; Lilley, 2007). Affecting the behavior of users through creating awareness on the detrimental effects of use (Eco-feedback), preventing unsustainable behavior through affordances and constraints (Eco-steer) and through automatically adjusting them with technology (Eco-technical intervention) are some examples of the strategies developed (Tang, 2010; Lilley, 2009). Through these strategies, this approach investigates the behaviors and habits of the users, and produces strategies to transform them into more sustainable ones (Bhamra *et al.,* 2011).

The way designers perceive users and their attitudes towards sustainable behavior was investigated by Lockton *et al.* (2012), presenting three user behavior models: pin-ball (i.e. passive user only responding to certain inputs), shortcut (i.e. users deciding on the easiest way of doing things) and thoughtful (i.e. analytically analyzing what and why they are doing, and able to change their behavior themselves). These models enable designers to understand different user behaviors and facilitate idea-generation for sustainable behavior change accordingly (Lockton *et al.*, 2012). Furthermore, designing for behavior change can target individuals separately, contexts to facilitate such a change for everyone, or a combination of individual and contextual (Niedderer *et al*., 2014).

Flower Lamp presented in Figure 7 was developed to encourage people to reduce their overall household energy usage. The design solution rewards users by blooming when the household energy consumption is reduced, or by de-blooming when the energy consumption increases (Backlund *et al.*, 2007). Thus, the users of this lamp need to make small changes in their energy usage for a more beautiful lamp (Backlund *et al.*, 2007).

Figure 7. Flower Lamp by Sofia Lagerkvist, Charlotte von der Lancken, Anna Lindgren, Katja Sävström and Göran Nordahl (retrieved on 29.06.2017, from http://www.designboom.com/design/visual-voltage-exhibition-at-design-vlaanderen-brussels/).

2.1.5. Social Innovation, Participation and Co-creation

Design for social innovation is an approach to enable transitioning towards sustainable life-styles through facilitating social change in communities (Manzini, 2015). Social innovation is the creative re-combination of available resources to reach socially-recognized and socially-desired outcomes. The approach is convergent with the participatory design, (Ehn, 2008), which encourages the participation of various actors to engage into the design process to find creative solutions to shared problems. The people taking part in the social innovation also takes on the roles of co-designers and co-producers throughout the projects. The social innovation can start bottom-up – with re-discovering the power of cooperation within a community and finding creative ways to recombine resources – or top-down – with institutional intervention and encouraging through strategical design. In all of them, the professional designer can become the co-designer of the processes *with* the community, or can take the lead and design *for* the community to initiate social change (Manzini, 2013; Manzini & Rizzo, 2011). Co-creation, as a participatory approach, acknowledges every stakeholder (i.e. designer, user, producer, etc.) that affects and is affected by the end-results (i.e. products, services, etc.) (Fuad-Luke, 2009) and investigates ways of collaboration among them, through tools and techniques which can be applied throughout design, production and post-use. Although these approaches shifted the way stakeholders are perceived throughout the design process, and encourage equal sharing of perspectives to build consensus; the quality of this collaborative action is important not only to reach a consensual agreement and decision making, but also to enable conflictual voices to be heard to stimulate innovation (Buur & Larsen, 2010).

Participatory design and co-creation approaches, although they have disruptive qualities on consumerism through the acknowledgement of the creativity of everyone and their involvement in design and production processes (Sanders *et al*., 2014), do not necessarily aim at sustainable solutions. Degnegaard (2014) in his literature review on co-creation points out a marketing and service stream, in which shows the transformative capabilities of user involvement can simply be reduced to marketing advantage through the sense of involvement in decision-making and co-creating values. Only through approaches like social innovation are these participatory approaches utilized to aim at creating alternative ways of living for sustainable futures.

2.1.6. Insights on Design for Sustainability

All the examples and approaches presented in this section aim at exploring alternative ways of living and creating a material culture, through questioning the way we produce and consume today. All the approaches situate the problem on the system-based solutions that passivize the users and redistribute the responsibility to institutional actors (like the Circular Economy Diagram in Figure 1), and offer alternatives ways of elongating product life spans through:

- creative ways of reusing and upgrading;
- producing through the involvement of local actors (e.g. craftsmen) and locally available resources;
- facilitating user intervention to alter and re-appropriate objects to meet their changing needs and preferences;
- urging people to recognize the detrimental effects of how they use products;
- involving everyone who are affected by the end-result of creative activity.

These approaches do not aim to downplay the importance of institutional actors; however, they also present the importance of all other actors and their involvement in every phase of creating a sustainable material culture. Only through the integration of different scales (from individual and local to mass-production scale) and the distribution of creative action among institutional and individual actors can we talk about a shift towards sustainable ways of living. This brings us to open design, a way of bringing together individual and institutional actors, and different scales, through the open sharing of knowledge to enable individual participation in collaborative act of creating.

2.2. Open Design

Open design suggests the participation of anybody interested, professional or novice, into the design process (Tooze *et al.*, 2014). In theory and practice, however, the approaches on open design, the participation of actors and the ways of participation vary greatly to suggest a definitive explanation of "openness" in any context (Von Busch, 2012). This section attempts to define open design and present its existing tools and methods to discuss its potential on the sustainability concerns of this study.

2.2.1. Open Design among Participatory Approaches

Through a historical perspective, open design emerged in the convergence of different approaches in design and in other areas. It regards users and other stakeholders as equal contributors/collaborators of the design process, similar to participatory design and co-design approaches (Stappers *et al.*, 2011; Fuad-Luke, 2009; Ehn, 2008). It takes further the freely sharing and adopting of design data that initially started with *Do-It-Yourself*

(D.I.Y.) movement evident in projects like *Nomadic Furniture* (Hennesey & Papanek, 1973) and *Autoprogettazione?* (Mari, 1974: 2014), and evolved through the accessibility of this kind of data thanks to Web 2.0 technologies and user-generated content (e.g. IkeaHackers.net, Openstructures.com; Instructables.com). It also adapts the continuous process, not focused on reaching one outcome but many, diverse iterations of the initially suggested idea, which is visible in *open-source software* movement (Raasch *et al*., 2009). Open design is in a unique position among participatory approaches, which will be explained in this section under three headers: (1) Contributors/People, (2) Processes, and (3) Outcomes/Parts & Objects.

2.2.1.1. Contributors/People

The participatory approaches, in general, transform the established roles of the actors involved with the design of a product (i.e. designers, users, producers). Started out to enable the subjects affected from a design to actually affect how that design turns out to be (Ehn, 2008), the participatory approaches have evolved to involve subjects more actively into the design process – as in co-design and generative design approaches (Sanders *et al.*, 2010; Fuad-Luke, 2009). The increased acceptance of participatory approaches in the industry is related to what Stappers *et al.* (2011) defines as the "contextual push". As the market is saturated through competition on technology and price, the companies have begun to take a closer look at users' experiences and contexts of use, and involve them in the (very) early stages of the design process to achieve a marketing advantage (Stappers *et al.*, 2011). The companies (or producers) also began to leave some of the final design choices to users through sharing design ideas online or making their product with some adaptability to respond such choices – as will be explained in further sections. Designers, in the midst of users and producers, began to require more skills on top of being able to deliver a design response: research skills to understand needs and desires of users, facilitator skills to manage the design process along with users and producers, and production process knowledge to point out different possibilities during the co-creation process (Stappers *et al.*, 2011). The roles of the designers, clients – the organizations that asks for design consultation – and users shift from the strict separation in the roles of actors towards more interactive roles (Figure 8).

As can be seen in Figure 8 (below), designer and client both become co-users, and user and client become co-designers. However, while user takes on the role of co-designer and becomes a part of the design process, s/he does not participate in the production processes (Figure 8). This perception of user as an active informant, or an expert on use experiences, who provides design ideas of sorts at the early stages of the design process is mostly visible in crowdsourcing approaches in the open paradigm – which will be introduced later in this section. Excluding users partly or entirely from creating the physical outcome of the design process raises a question: *to what extent users can be involved in the life-cycle of a product other than using it?*

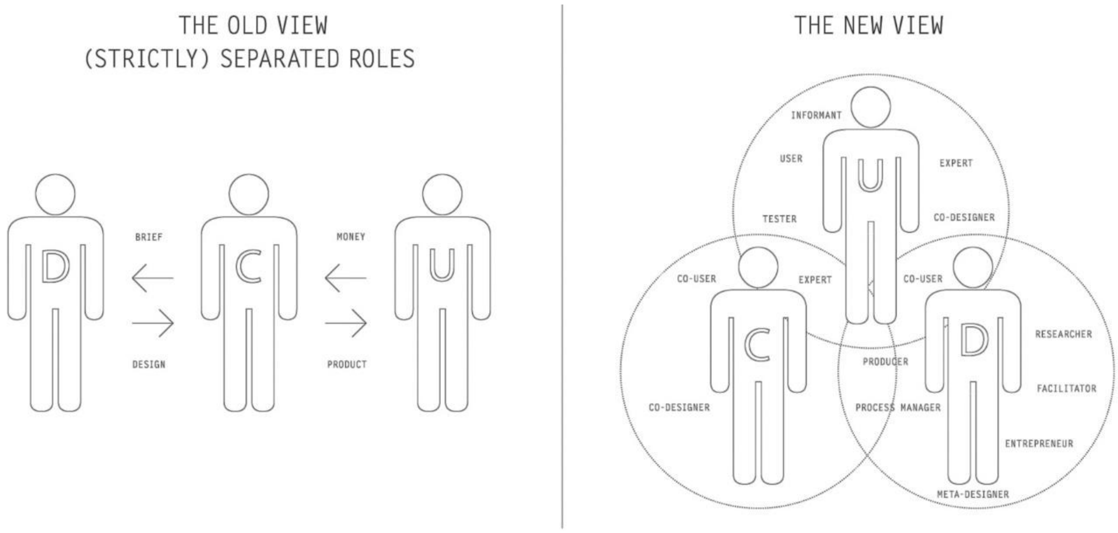

Figure 8. The Old View: (Strictly) Separated Roles and the New View: Interacting Roles and Responsibilities (Adapted from Stappers et al., 2011).

In their paper, questioning the changing roles of stakeholders through participatory and co-design approaches, Sanders *et al*. (2008) present the level of creativity users can show (Table 1). According to these levels, the highest level of creativity (Level 4: Creating) enable users to become co-designers, as they are able to dream new ideas and have the capability to express and realize it to some extent. However, they claim that users "may be at the *creating* level when it comes to cooking but at the *adapting* level when it comes to the use of technology products" (Sanders *et al*., 2008, p. 12), while pointing out the limited capabilities of users in creating complex products. `

Table 1. Four levels of creativity (Adapted from Sanders et al., 2008).

Level	Type	Motivated by	Purpose	Example
4	Creating	Inspiration	'express my creativity'	Dreaming up a new dish
3	Making	Asserting my ability or skill	'make with my own hands'	Cooking with a recipe
2	Adapting	Appropriation	'make things my own'	Embellishing a ready-made meal
1	Doing	Productivity	'getting something done'	Organizing my herbs and spices

The changes in open sharing of design knowledge and the reachability of fabrication tools for end-users help them overcome this obstacle to creativity to some extent when it comes to complex products. Campbell (2005) talks about the rise of the *craft consumer*, a person who takes mass-produced products and uses them as raw materials to create a new object that is intended for self-consumption. He points out the rise of DIY movement and its expanding capabilities thanks to the reachability of tools and materials as an important driver for the *craft consumer* to turn mass-produced products into personalized objects. Beyond creating objects for self-consumption, von Hippel (2005) talks about the innovative propelling potential of *lead-users. Lead-users* are a small percentage of users of a product who modify and/or re-design the products according to their needs and preferences beyond what the market provides. Furthermore, the development of user-to-user (or peer2peer) communities provides useful structures and tools for further development and dissemination of innovative solutions developed by *lead-users*, providing them with the chance of turning their modifications into profitable businesses (Von Hippel, 2005). Apart from the users' ability to turn their ideas into marketable innovations with less available monetary or physical resources, open design presents the potential of bottom-up organization of collective creation and production of physical objects, which are open to everyone's contribution regardless of their backgrounds (Maldini, 2012). This bottom-up organization can, in turn, help people develop new skills, share tools and patterns, find local production, repair and upgrading opportunities.

On the other hand, being able to make open design contributions and/or being able to make use of the open design solutions are issues of varying capabilities in conveying knowledge and experience, reaching production equipment, having required skills for design, production and assembly, and so on. Hence, alternative systems for open participation should be designed, which are easy-to-reach and easy-to-contribute to encourage people's contribution (Aitamurto *et al.*, 2015). The openness of the design process and design solutions, then, is not only about being without restrictions, but also about building capabilities and encouraging contribution. The citizen science approach uses non-professionals to conduct research about their surroundings and provide insights and ideas in an open design process (Phillips, 2015). Peer-production approach and Digital Fabrication Labs around the world provide users with not only the necessary fabrication tools but also a community that can learn from each other how to operate these tools and how to materialize a project-at-hand (Wolf *et al*., 2014). Repair Cafés (repaircafe.org, n.d) and other initiatives alike, as well as open knowledge sharing platforms like iFixit (ifixit.com, n.d), help people learn from each other to repair and refurbish broken down products. These examples are what forms an alternative economy of open knowledge that empowers the users to become user-researchers, user-designers, user-producers and user-repairers.

2.2.1.2. Processes

In his 1983 article, Christopher Jones depicts a design process, inspired by the evolving software technologies and their process of making, changing, modifying and updating. He pinpoints that a continuous process of designing and redesigning can respond the changing contexts and needs, if the purpose of any designer is the process (Jones, 1983). He also mentions the instability of requirements in the process of designing – the requirements change along with the process as they are not predictable wholly at the beginning – and divergence can be achieved through collaborative designing (Jones, 1983). The outcomes throughout this (open and) continuous process need to be *pre-hacked*, with the ability to be modified and personalized (Richardson, 2016).

Open design concerns itself with the contribution of anyone – including the user – throughout the design and production process. The form of the contribution varies greatly according to the capabilities and knowledge of the contributors; however, the design itself should be open to any form of contributions, modifications and adaptations. To eliminate any kind of confusion, I plan to use the terms brought together by Tooze *et al.* (2014) (Table 2).

Table 2. Terms for open design (adapted from Tooze et al., 2014).

Co-creation	The generation of anything by more than one person
Co-design	The design of something by more than one person
Open Innovation	Being open to and seeking out contributions of others outside of an organization for the purposes of bringing in new ideas
Open source innovation	The open sharing of design information or knowledge by an organization with collaborators as part of open innovation
Open design solution	A set of plans and instructions that enable others to make use of the 'design solution' without restriction *(a design solution is something that can acted on directly and in the context of physical things, be made)*
Open design contribution	Any contribution, in any format, to a design process that is made available for use by others without restriction
Open design process	The development of an open design solution or solutions that are created by the input of open design contributions
Open designing	Engaging in the design of anything by an open design process
Open design project	Any project that follows an open design process

The shift in the role of users mentioned by Stappers *et al.* (2011) – active informant and expert of use experience – fits into the co-creation, open innovation and/or open design contribution in Table 2. However, the openness of a design solution is defined with the ability to make use of it without any restrictions, to modify the design or use it as it is. Hence, the openness of a design solution is defined by the opportunities it creates for anyone, rather than its being open to participation throughout the design process. Tooze *et al.* (2014) gauge the openness of a design project through evaluating the process and the end-result (Figure 9).

A completely open design project is identified with only including open design contributions and producing open design solutions. In Figure 8, *various derivations from an open design solution* part is especially important, as that is the part where we can observe how an open solution can be modified and/or personalized – following upon the discussion on continuous design (Richardson, 2016; Jones, 1983). In addition, as long as the contributions are open (transparent and shared), they can be replicated (i.e. implemented or adapted) in other design processes and solutions. In this sense, any design related knowledge in an open process should be created in a way that presents every aspect, shared openly (i.e. open to use and modify). In return, this open design contribution or solution can be implemented by other people as it is, or adapted to respond to their needs and preferences.

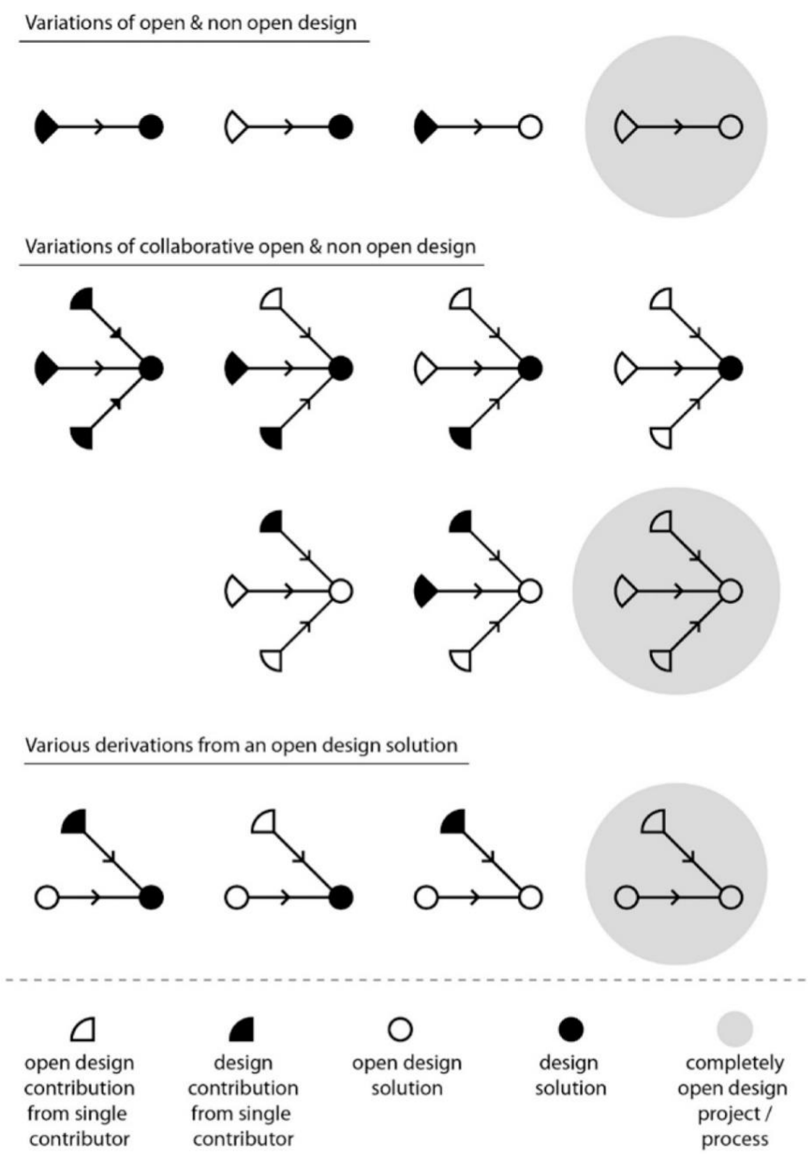

Figure 9. Visualizing open and non-open aspects of design processes (Adapted from Tooze et al, 2014).

2.2.1.3. Outcomes/Parts and Objects

Previous sections outline how open design regards contributors (i.e. people with diverse backgrounds and different expertise levels) and how it presents a continuous design process open to different kinds of contributions. In this section, the purpose is to unravel the nature of contributions and outcomes as parts and objects.

What Richardson (2016) calls *pre-hacked*, is a condition of objects that are not sealed off as a black-box. The parts or components of an object should be reachable, modifiable and replaceable, which results in the reformulation of the object itself as a never-finalized design outcome. Raasch *et al.* (2009) explains this as the strong aspect of open design through modularization: anybody can work on any part of the design process, and if a part of an open design solution is too hard to crack or realize, it can be simply passed on to someone else who can design or produce it. In this sense, these solutions are not professionally designed set of parts to achieve modular designs – as we can see in some modular solutions used for mass-customization – but rather they are parts designed and produced by different individuals, groups of individuals, local producers, etc. that can be brought together for different purposes in different contexts through shared templates or standardized assembly details. At this point, the openness of parts and objects need to be questioned. Back in 2009, an initiative called Open Source Hardware and Design Alliance (OHANDA) attempted to define the openness of hardware, modeling it after the Software Freedoms used in open-source software (Stallman, 1999). This attempt aimed at creating norms around open design and sharing of design-related knowledge. The Freedoms are as follows:

- **Freedom 0:** The freedom to use the device for any purpose.
- **Freedom 1:** The freedom to study how the device works and change it to make it to do what you wish. Access to the complete design is precondition to this.
- **Freedom 2:** Redistribute the device and/or design (remanufacture).
- **Freedom 3:** The freedom to improve the device and/or design, and release your improvements (and modified versions in general) to the public, so that the whole community benefits. Access to the complete design is precondition to this (OHANDA, 2009).

Based on these freedoms, OHANDA also introduced the OH&D trademark and a marker-based platform to share the knowledge (i.e. design data, other documentation, list of bills, etc.) (OHANDA, 2009). Overall, the purpose is to create a trademarking system to ensure the open sharing of design-related knowledge. Furthermore, creating legally protected open knowledge is important to ensure that knowledge stays open and legitimizes it. Open design has the potential to bring together knowledge across social and professional boundaries, through Open Hardware Licenses (OHL) (e.g.

GPL, CERN-OHL, etc.) (Powell, 2015). These licenses, if they are legitimized through constituted authorities, like CERN in CERN-OHL case, can create legal frameworks that "valorizes distributed, peer produced knowledge" and support the move of cultural production from institutions to emergent collectives and/or communities (Powell, 2015, p.391).

Ensuring the open design related knowledge becomes no one person's or institution's property does not provide us with enough practical implication on their openness to achieve continuous, open design process. Raasch *et al*. (2009) identifies the openness of parts as open, partly open and closed. Open parts are the ones with complete access to their design-related knowledge (e.g. exact dimension, CAD files, ways to produce, etc.) and enables modification, while partly open parts are the ones with some withheld information to prevent the modification of them but enable their use and reuse in different contexts (Raasch *et al*., 2009). An open design solution can consist of a combination of open, partly open and closed parts, as long as how it is constituted is shared, and open to modification and reuse.

2.2.3. Open Design and Sustainability Relation

Open knowledge sharing is thought to facilitate cooperation among different, disconnected institutions around the world, which work towards a sustainable future (Pearce, 2012). It challenges the way material culture has been created ever since the industrial revolution and suggests a dispersed network of people working beyond the limitations of time and space, through limitation-free sharing of knowledge (Pearce, 2012; Pearce & Mushtaq, 2009). In the case of design, open part and product designs can be altered and personalized by and for different people, can be repaired when they are broken and can be developed further, thanks to the possibility of intervention and openly available knowledge (Thackara, 2011). Sharing open design solutions and knowledge about them can initiate constitution, development and especially dissemination of alternative, sustainable lifestyles and economies (Manzini, 2015; Thackara, 2011). There are two aspects of open design that present these potentials for sustainability, which are explained below.

2.2.3.1. Global Solutions Adapted to Local/Individual Problems

Open design knowledge, shared throughout the world, enables one obvious potential: it can be adapted by different localities according to their own needs, preferences, skills and resources. Johansson *et al*. (2005) mentions the implications of D.I.Y. for generating locally-bound value chains and a distributed economy. This also goes hand-in-hand with the use of locally-available resources, and shorter transportation of materials and parts (Bonvoisin, 2016). The advances in easy-to-reach desktop manufacturing technologies (i.e. 3D printers, laser-cutters, etc.) facilitate a shift towards demand-driven production – rather than a supply-driven one – by allowing localization of production (e.g. makerspace, individual manufacturing, etc.) (Kostakis *et al.*, 2015). The localization of production also enables the participation of end-users in design and production of objects, responding to functional and aesthetic needs of users and promoting product longevity (Bonvoisin, 2016). Furthermore, local knowledge on design and production (e.g. local craftsmen/producer) can be integrated and exchanged with globally shared open knowledge, through commons-based sharing (e.g. General Public License, CERN-OHL, etc.) resulting in the rapid innovation cycles and the elimination of planned obsolescence (Kostakis *et al*., 2015; Bauwens *et al*., 2014).

All these are convergent with the *localization* and *personalization* aspects of design for sustainability. Through the integration of different scales of design and production (i.e. individual production, local craftsmen, regional batch production, and mass-production), localization aspect advocates the development of design solutions that support local economies, respond to local and individual needs and preferences, and enable access to post-use services (i.e. repair, refurbish, upgrade) (Doğan & Walker, 2008; Doğan, 2007). With the direct involvement of users, personalization aspect aims to strengthen the bond between users and objects, and through upgrading and refurbishment the objects can respond to changing needs and preferences (Ozan & Doğan, 2014).

2.2.3.2. Reachable/Repairable Parts and Components

As mentioned before, open design process assumes the modularization of parts and components, not only in the functional sense, but also with regards to their development and production (Raasch *et al.*, 2009). It does not only allow the grassroots, innovative process of open design, but also enables reachability of parts and components in any combination they are brought together. The part designs themselves are openly shared and reachable, as well as the way they function, their assembly details, their requirements, their material information and production – this information is secured to remain open through the OHLs as well (Powell, 2015; OHANDA, 2009). In theory, it allows the continuous design and redesign process (Richardson, 2016; Jones, 1983) and in practice, it ensures the reparability of parts – through the shared information necessary for the repair of one part – and objects – through the modularity it creates to replace parts of an object. Furthermore, the shift from supply-driven process to production for individual demands, the idea of planned obsolescence is eliminated and longer lasting parts and objects are promoted (Bonvoisin, 2016; Kostakis *et al.*, 2015). Finally, these longer lasting, modular parts can be salvaged and reused in different combinations to create different objects – an iteration of the initial design solution or a different solution for a different purpose. The above-mentioned aspects of open design are convergent with enabling reuse and upgrading aspects of design for sustainability, as they allow part longevity through modularity, enable upgrading of objects along with the changing needs and preferences and enable the reuse of parts of an object once the object is no longer needed or wanted.

2.2.4. Tools, Methods and Approaches for Open Design Processes

The openness throughout the design process is emphasized in literature (Aitamurto *et al.*, 2015; Tooze, *et al.*, 2014) and there are several methods used in different stages of the design process. Following the concerns mentioned in the previous section, on the openness of design process and people's capabilities to contribute, these methods are being used in practice and they present potentials in opening up the design process (Table 3).

Table 3. Open Design Methods from the current applications for marketing, production and consumption (Adapted from Aitamurto et al., 2015).

Design Phase	Methods
Need-finding	• Crowdsourcing needs (e.g., in online communities through interactions with end-users) • Ethnographic methods
Ideation and concept generation	• Publicly open brainstorming • Crowdsourcing and co-creation of concepts • Crowdsourcing evaluations and discussions of ideas • Co-creation of concepts by users and with users • Testing problem-definition with users
Detailed design	• Crowdsourcing designs • Co-creating prototypes with customers, users, and online participants and testing prototypes with them
Manufacturing	• Mass-customization and personalization of designs
Distribution	• Open licensing of content, code, and design specifications (e.g., by using Creative Commons licenses, FOSS licenses, and OSH licenses)
Testing	• Crowdsourcing feedback from users • Opening prototypes for testing • Co-creating redesigns/improvements of prototypes
Commercialization	• Applying the principles of open innovation (e.g., in licensing, open APIs, marketing)

A quick look at the Table 3, it is easy to see the overuse of the terms *crowdsourcing* and *co-creation*. In addition to those, the terms *mass-customization* and *personalization* are used only in manufacturing phase of the product life-cycle and *open licensing* in distribution and commercialization phases. I believe this table should be perceived as a compilation of currently used models in the market and not as a concrete methodology of what it can become. It should also be noted that some of the above-mentioned terms are not methods or tools *per se*, but rather they are approaches to encourage participation of users. For example, *personalization* is an approach that is also one of the sustainable design approaches mentioned before, which can result in emotional durability and product longevity, and encourage sustainable behavior through answering specific needs and desires of a user. Yet, in the context of open design, it is an approach not necessarily related to sustainability, but rather a way to democratize design through enabling users to change and adapt designs to fit their needs and preferences. Considering this change in the perception of terms and the aims of this study to understand the implications of open design for sustainability, I have compiled the approaches to open design according to the kind of participation they call for under three headings – (1) enabling non-professionals to participate in research and idea-generation, (2) enabling design interventions through sharing, and (3) standardization of design – and presented their brief definitions below (Table 4).

Table 4. Approaches in open design according to the kind of participation.

Approaches in Open Design	**Tools and Methods**	**Definition**
Enabling non-professionals to participate in idea-generation	Crowdsourcing	People evaluating design solutions to various problems and providing their opinions/insights about them
	Online Collaboration	People finding design solutions together to various problems through bringing together their expertise on different subjects
Enabling design interventions through sharing	Design data sharing	Sharing of design schematics and/or digital files available to everyone, to enable re-production of designs in different contexts and/or with different materials
	Design hacking	Sharing ways of intervening into the design of already-produced products to improve their usability or to adapt them for different purposes
	Mass-customization	Intervening into the production of products to a limited extend to match own needs and preferences
Standardization of design	Shared Design Guidelines	People designing parts and products according to shared guidelines and standards to make inter-changeability and re-use of parts possible

Table 4 (above) can be considered as an attempt to systematically categorize the approaches in open design according to the kind of participation they expect from people. In the current applications, openness is utilized throughout the design process or the process can be opened only on specific stages. It can also be utilized through hacking into existing, initially closed products to enable people's intervention. In the remainder of this section, I will present some examples of these approaches and discuss their potentials for sustainability.

2.2.4.1. Crowdsourcing

Crowdsourcing is a problem solving method that utilizes a crowd to help solve a problem that is defined by a *crowdsourcer* – a certain individual, institution and/or company that asks for the help of the crowd (Brabham, 2013). The way people can contribute to the crowdsourcing activity varies according to the kind of help needed. A simple example is Threadless (Threadless, n.d.), which is an online t-shirt seller.

The website works with two streams of contributed information: (1) design contributions from the designers, and (2) voting of the designs by the customers. In the first stream, designers are asked to submit their T-shirt designs and offered a percentage of the sales profit if their designs end up being produced. The customers give scores to the submitted t-shirt designs to decide which designs will be produced. When the designs get a certain score, they begin to be produced and sold (Threadless, n.d.). The crowd in the case of Threadless only evaluates submitted design works through giving them scores. People only choose which designs are going to be produced, yet they cannot interfere with the design process directly to adapt and/or improve those designs, or choose materials or production processes. The problem in this case is choosing the right design that is desired by the market.

Crowdfunding is another kind of crowdsourcing, in which the problem is the funding necessary for a project to be produced. In the case of KickStarter, new ideas are published online with a rough estimate on how much the production will cost and people are asked to 'invest' into these ideas (KickStarter, n.d.). People's way of contribution is procuring funds for the necessary research and development, just because they want the idea to come to life, and in some cases, to pre-order the outcome way before it is realized. Instead of the scoring – like the Threadless example above – people show their admiration and desire towards the idea by literally paying for it come to life (Ordanini *et al.*, 2011).

The widespread use of crowdsourcing is in the form of evaluation of design ideas through scoring and commenting. Even though the comments help designers in assessing the success of a certain design, it does not necessarily lead to the improvement of that design. Rather, it provides data on the users' preferences. Thus, crowdsourcing can be considered as a form of design research to find out the most prominent design idea among many.

2.2.4.2. Online Collaboration

Another way of involving users to participate into the idea-generation phase of the design process is the online collaboration platforms, like OpenIDEO. The biggest difference between crowdsourcing and online collaboration is the latter's purpose of developing ideas beyond simple evaluation, as they ask for insights, ideas, design details, production possibilities, etc. (OpenIDEO, n.d.). In literature, both of these approaches (i.e. crowdsourcing and online collaboration) are studied under the general title of crowdsourcing, however, it is necessary to differentiate them to understand the level of openness they separately provide.

Through the challenges created by a client through a platform, an online community is asked to collaborate on different steps of the idea-generation. In the case of OpenIDEO, the steps of sharing are research, ideas, refinement, feedback, top ideas and impact. The process starts with a challenge to which the online community responds with various users' inputs in the form of stories, tools, inspirations, etc. (i.e. research step) and later with various ideas (i.e. ideas step). After that, these ideas are developed with the feedbacks provided by the online community (i.e. refinement and feedback steps). Finally, the top ideas are selected for further development by the client (i.e. top ideas step) and the online community elaborates on the collaborative process (i.e. impact step) (OpenIDEO, n.d.). This model of collaboration is considered beneficial for everyone in the community of contributors, in which more ideas are generated through a pool and the most suitable ideas are given a chance to be realized, creating a possibility of recognition for professionals and a chance of creating products and services desired by users. Certainly, it is most profitable for the clients, as their research and development costs are lowered and they are provided with many ideas approved by a community of professionals and users, which they would not be able to generate by themselves.

Although these approaches provide opportunities for creating and evaluating ideas by a considerably large group of professionals and end-users through open collaboration, the problem of exploitation of the end-users surfaces. Design process outsourced this way mobilizes large groups of people, and utilizes their skills and insights for the development and evaluation of design ideas, yet these collaborators are selectively compensated according to the quality of the contribution they provide, which is assessed by the client (Kleeman *et al*., 2008). On the other hand, both crowdsourcing and online collaboration tools are great ways of reaching many individuals around the world and finding the 'best' idea for a given problem. If the problem in question is formulated for greater challenges (e.g. social equity and environmental degradation) – instead of product and service development for a company – these tools have the potential to find solutions that may help transitioning towards sustainability.

2.2.4.3. Design Data Sharing

Sharing design data (e.g. blueprints, explaining production methods, etc.) is an approach to make designs accessible to producers and users, and enable them to be reproduced in different places and times. In this section, two different approaches on design data sharing will be given along with their implications: Thingiverse and Design for Download.

The current state of 3D printers, their abilities in printing 3D parts, their ranging material selection possibilities, present a potential in enabling users to produce parts and products in their homes and/or locally at 3D printing services. The users may not use CAD programs effectively; hence, platforms like Thingiverse enable the sharing of CAD models to be 3D-printed by people (Thingiverse.com, n.d.). Through the Thingiverse platform, people can share various designs, and can download these designs to fabricate using a 3D printer. The designer who shares a part can also make those CAD models customizable, through setting parameters, in an app called the Customizer (Figure 10).

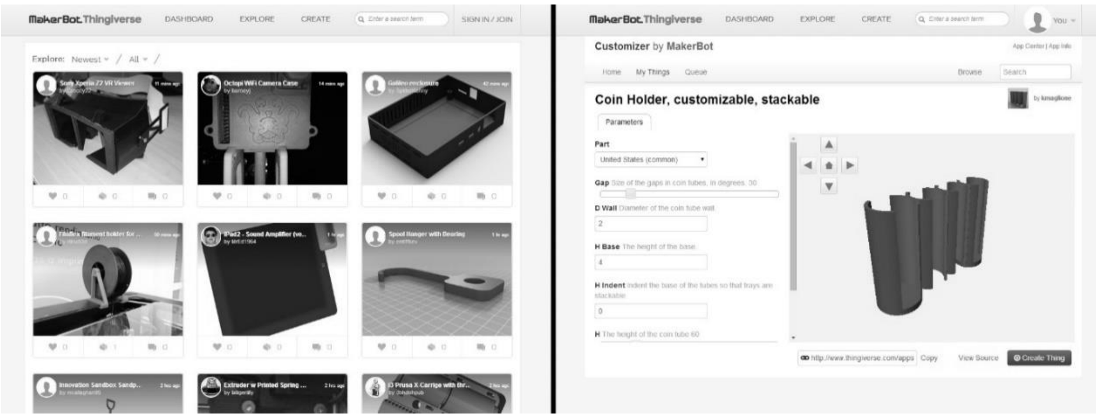

Figure 10. Thingiverse Explore page (left) and Thingiverse Customizer app (right) (retrieved from thingiverse.com, on 14.05.2014).

The other example, Design for Download, is a currently developing platform by Droog Design (Studio Droog, 2011). The platform “will feature curated and open content, easy-to-use parametric design tools and a network of local low- and high-tech manufacturers” (Studio Droog, 2011). Although the platform was announced, it has not become online yet, thus it is not clear how much of the designing will be enabled for the non-professionals through the mentioned easy-to-use parametric design tools. On the other hand, the platform aims to offer two kinds of design data – open and curated. The curated data on the platform aims to ensure the quality of designs and the commercial viability of the platform (Meroz & Griffin, 2012).

Sharing the data itself is not enough in itself, thus, these platforms are built around fabrication equipment that users can procure – as in the case of 3D printers and Thingiverse – or they can suggest producers available in different localities – like in the case of Design for Download. The problem of accessibility to fabrication possibilities lies under such platforms, as not everyone has the skills, knowledge and/or resources to procure and process materials into parts and products. Another crucial point of these platforms appears to be the static nature of the shared design data. Although both platforms offer some kind of usability and flexibility by setting parameters to alter the design data, people cannot interfere with the design outcome like they could, if they were collaborating with the designers in an open process from the beginning. Consequently, these platforms become an extended version of the IKEA model – in which the assembly of the parts is outsourced to the users – by outsourcing the material procurement and processing.

2.2.4.4. Design Hacking

Design hacking is another approach in design intervention, in which existing products are regarded as ready-made materials instead of finished products. What makes this approach open is the sharing of the hacking process, which can be used by people as models to hack the same or similar products. This approach, unlike design data sharing, does not solely rely on the fabrication capabilities that people possess or have access to, to reproduce an existing design, but also creates the possibility of varying design interventions by pointing out possible intervention areas for an existing design.

A good example of design hacking is an online blog called IKEAhackers, in which various contributors can post about their experiences in modifying and repurposing IKEA products (Figure 11). The contributors can share any kind of design modification they practiced, and these modifications can be easy and small or hard and complex. The contributors are asked to grade their contributions according to their hardness levels, from “easy-peasy” to “bring it on!” (Ikeahackers.net, n.d.). Although posted hacks can be implemented as they were posted by the people, these posts also point out the modification possibilities of existing products and inform people on the challenges they may face, if they undertake such modifications. Consequently, people can adapt existing products to their preferences and needs through modifying and repurposing.

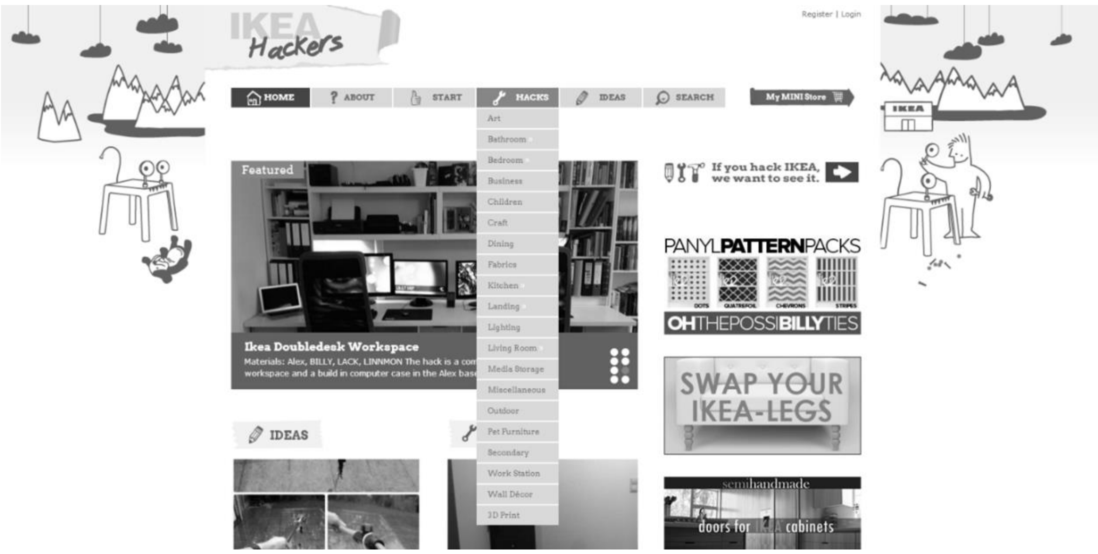

Figure 11. A screenshot of the Ikeahackers.net blog (retrieved from ikeahackers.net, on 14.05.2014).

This approach is not co-creation *per se*, as already designed and produced objects are regarded as material input to create something else. However, it can be considered as a tool to inform and empower people through showing how to hack existing products and re-form or re-contextualize those products in ways different from the designers and producers intended.

2.2.4.5. Mass-customization

Mass-customization is a common marketing concept that emerged to satisfy the demand of personal attachment to the objects that people will feel connected and get what they actually demanded (Kratochvil & Carson, 2005). Evolved from the fragmentation – differentiated products representing different (self-) images that change according to time and context (Firat & Schultz II, 1997) – in the sense that it offers differentiation beyond the marketing trends. An example of this approach is from the mobile communication market. Cell phones blended in to our lives not only as a utilitarian object but also as an extension of our body, as a part of our self-image. This first started with the introduction of different ring-tones to the market. People began to customize their cell phones with those ring-tones and appropriate them to their self-images (May & Hearn, 2005). This was also one of the earliest advanced forms of customization, addressing to a wide-ranged cluster of (self-) images with just one product and just one piece to change. It was not long after that, the cell-phone market met with the changing outer casings, in which the device as a utilitarian object proved to be insufficient and people began to customize them through changing the whole appearance of the device. At this point onward, the (self-) images became a driving factor in the marketing approaches for cell phones. Research made in this area have proved that style and the possibilities of appropriation of the object to different (self-) images have actually become what actually matters for the consumers' choice (Katz & Sugiyama, 2006; Fortunati, 2002).

As a continuation of the above mentioned, a new project is currently being developed that expands the mass-customization possibilities of cell phones to actually combine various features according to the users’ needs and preferences. Started out as a crowd-speaking design concept in September 2013, PhoneBloks is a modular cell-phone concept as a means to enable easier post-use services (i.e. repair and upgrading) to reduce e-waste (Figure 12). The concept calls for an open-source platform in which all the cellular phone producers abide to certain design limitations and which enables everyone – locally and globally – to join in the production of both the parts and the phones.

Figure 12. Phonebloks concept by Dave Hakkens (retrieved from phonebloks.com, on 14.05.2014).

In the above-mentioned example, the standardization of component assembly details enables mass-customization with a twist of upgradability and easier part replacement opportunities. The open-source platform lets producers of different scales to produce different parts and enables users to easily combine different parts that matches their needs and preferences. However, it is a platform that needs to be built and retained by a company, and all the parts that can be produced by other companies need to be approved by the owner(s) of the platform. At this stage, there are two different limitations of such a platform: formulated as it is, (1) the platform can turn into a business-as-usual model and (2) can lead to unsustainable or mass-consumption patterns as people tend to change/replace these parts even if they do not need upgrading.

2.2.4.6. Shared Design Guidelines

Sharing design guidelines that everyone (i.e. users, designers and producers) abide to is a different approach in open design. Similar to creating a platform for people to contribute to in the PhoneBloks example (above), in this case people design parts according to a set of design rules instead of design limitations (e.g. pin locations, limitations on form, etc.). These kinds of guidelines aim at flexibility while creating new possibilities in bringing together parts designed for different purposes. A good example of sharing design guidelines is the OpenStructures Project: an experiment towards the idea of standardization of design. Through offering a shared modular grid, the aim is to stimulate exchange of part designs, produced parts and experiences of contributors to aspire building things together. The project is started to find out the possibilities and limitations of such an open modular system in designing and producing products (OpenStructures, n.d.). Everybody can become a contributor and share their part designs – which are designed according to the shared modular grid – and various configurations of parts.

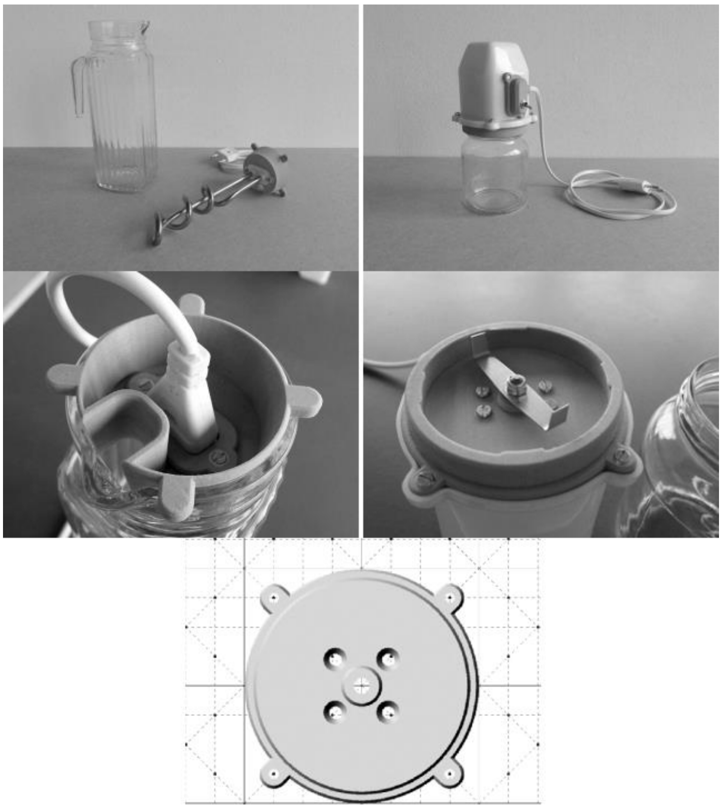

Figure 13. A product part design on the OpenStructures shared modular grid and two different products the part is used for, by Jesse Howard, 2012 (retrieved from http://blog.openstructures.net/pages/transparent-kitchen-tools-by, on 14.05.2014).

For example, in Figure 13, how a part can be used for two different products can be seen. The part at the bottom was prepared according to the shared modular grid, which also includes instructions on the dimensions of the features like holes, thickness, radius, etc. The part is used for an electric kettle on the left and a chopper on the right.

Different ways to assemble these parts for different purposes are exemplified in the blog section of the project, encouraging users and designers to contribute to the project.

Through the shared design guidelines, the design practice is standardized to enable people to contribute from the very early stages of the idea-generation up to the production and assembly of parts. If someone lacks the necessary skills in any stages, they can just use shared designs or procure the components from other contributors. The shared modular grid is not steered towards any type of product, and it offers flexibility in designing parts for very diverse purposes.

2.2.5. Implications of Existing Open Design Tools, Methods and Approaches for Sustainability

The previous section introduces tools and methods utilized under the umbrella term of open design, and discusses their potentials and limitations for sustainability. These methods and tools present diverse potentials for product/part longevity, personalization and part reuse, as well as limitations, which are summarized in Table 5.

Table 5. Methods and tools for open design and their implications for sustainability.

Approaches in Open Design	**Methods and Tools**	**Potentials for Sustainability**	**Limitations for Sustainability**
Enabling non-professionals to participate in idea-generation	Crowdsourcing	Understanding users' needs and preferences and finding locally-tailored or target-user oriented solutions	The users are only involved in the evaluation of the outcomes. The evaluation criteria are created by the *crowdsourcer* (e.g. company), generally focused on marketing
	Online Collaboration	Finding appropriate solutions through making use of different expertise of people Understanding users' needs and preferences	Selective compensation of individuals and exploitation of end-users for getting more feedback. Although solutions are generated and assessed by the online community, assessment criteria are given by company, generally focused on marketing potential.

Table 5. Methods and tools for open design and their implications for sustainability (continued).

Enabling design interventions through sharing	Design data sharing	Parts and products can be fabricated with different locally-available production techniques Parts and products can be fabricated with different locally-available materials	Shared design data can only be altered within pre-defined parameters. Basically, outsourcing the material procurement and processing to individuals.
	Design hacking	Personalization of mass-produced according to individual's needs, preferences and desires. Can be used as a way to reuse mass-produced items, rather than disposing of them.	Outcomes are dependent on the affordances of initial design.
	Mass-customization	Acquiring design solutions/ products as close to individual's needs and preferences as possible on mass-scale	Parts are not open, they are mass-produced and has no room for intervention.
Standardization of design	Shared Design Guidelines	All matching parts and products that can be brought together in different combinations for different purposes The parts can be disassembled and used in different combinations	The retail parts (e.g. motors, heaters, etc.) need to be taken into account in the shared grid as well. The parts and their durability in different combinations are not questioned.

These possibilities and limitations are mostly theoretical, especially because there are not many cases the open design process is carried out as a continuous designing and re-designing process. The methods and tools in *enabling design interventions through sharing* and *standardization of design* categories present the potential for a continuous design process, however their outcomes (i.e. solutions and their iterations) were not critically explored from a sustainability perspective.

2.3. Open Design Process for Product/Part Longevity, Personalization and Post-use

The affirmative relation between design for sustainability and open design is already mentioned in *Section 2.2.3. Open Design and Sustainability Relation.* Open design, however, is a vast approach which includes questionable tools and methods that can be limiting (e.g. crowd-sourcing, design data sharing), exploiting (e.g. online collaboration) or just another way of marketing (e.g. mass-customization). On the other hand, they may challenge mass-production and mass-consumption through reachability of design knowledge and being open to everyone's contribution. However, the current focus of these methods and tools may not have any considerations beyond the sharing of design knowledge through a common ground (e.g. shared design guidelines).

As a result, in this PhD study, I have explored the implications of open design for its theoretically discussed potential on sustainability. This continuous design process can involve various people around the world through empowering them with design knowledge sharing. It can manifest open solutions and iterations that can be altered to respond to needs and preferences of different individuals. It can do so without replacing the whole assemblage of parts, but by only changing some of them and reusing others. The question of how to design open parts and products for such personalization, reuse and longevity is a question that needs to be further explored through the process and the outcomes. In order to explore the implications of not only the open design solutions but also the iterative process of open design, I have adopted the methodology presented in the next chapter and focused on development of conceptual open, sustainable design solutions for the kitchen practices.

CHAPTER 3

METHODOLOGY

As presented in the literature review, open design is considered to have similarities with social aspect of sustainability through limitation-free sharing of design data and open-to-all design processes it advocates. On the other hand, being able to reach shared design data and contributing to an open-to-all design process do not automatically take into account the environmental aspects of sustainable design, like elongating life spans of parts or products through personalization or enabling post-use processes. It can also de-power the users through distributed responsibility and unrecognized labor (Aitamurto *et al*., 2014; von Busch, 2012) and result in a vast array of waste (Thackara, 2011). This is the case for established, widespread product categories, like small kitchen appliances, which are the focus of this study. Thus, the purpose of this whole study is to explore how the theoretical ground of open design can expand to include these sustainable design concerns too. In this chapter, the methodology adopted for this PhD study is introduced, along with reasons for selecting this methodology, and the limitations and opportunities it presents. The chapter starts with introducing *research through designing* and how it was adapted as *research through co-designing* to fit the needs of this study. It, then, continues with the adopted data collection and analysis tools and techniques, discussing their use and appropriateness.

3.1. Research through Co-designing

This PhD study explores practical implications of open design process for sustainability, specifically product/part longevity, design for personalization and design for post-use. Open design process, as defined in literature review chapter, is a co-design process without any limitations on the kind and scale of contribution, the skills of the contributor, locality, time, etc. and an ongoing process with many iterations of a design idea or solution, rather than a finalized design process with an agreed-upon outcome. Hence, exploring the implications of such a co-design process is different from exploring the implications of a notion, concept, etc. through one's own design practice, as exploring open design ultimately requires the adoption of design solutions by other potential contributors and the alteration of the initial solution into varied iterations. This is different from the research through designing studies adopted by designer/researchers, as the process requires more than one person developing or altering a design solution to be explored. In the following sections, I will explain the potentials of research through designing and how *research through co-designing* method is adapted for the goals of this study.

3.1.1. Research through Designing

Emerged from Frayling's categorization of design research (1993), research through design is regarded as a form of action research which generates communicable knowledge through systematically undertaken design practice (Archer, 1995). Two different levels of knowledge can be generated with research through designing: the designed objects and the process of designing (Frens, 2007), both of which are important within the context of this study with regards to developing open design process for sustainability (particularly for kitchen appliances), open, sustainable design considerations and exploring open part properties that respond to these considerations. In this section, action research and research through designing will be explained in detail and my plans for utilizing research through designing will be explained.

Although action research can be used to simply improve efficiency, it presents a greater potential in transforming design practice (Crouch & Pearce, 2012). An important principle of action research is that people's practices can be changed to deliver more ethical, socially-just, sustainable results (McNiff & Whitehead, 2006). Action research can be used to produce new theories, but can also be used only to develop relevant solutions to identified problems. Although it differs from design practice with its systematic nature, the research design for action research remains flexible and is decided as it proceeds. Action research cycle consists of four steps: Observing, Reflecting, Planning and Acting (Figure 14).

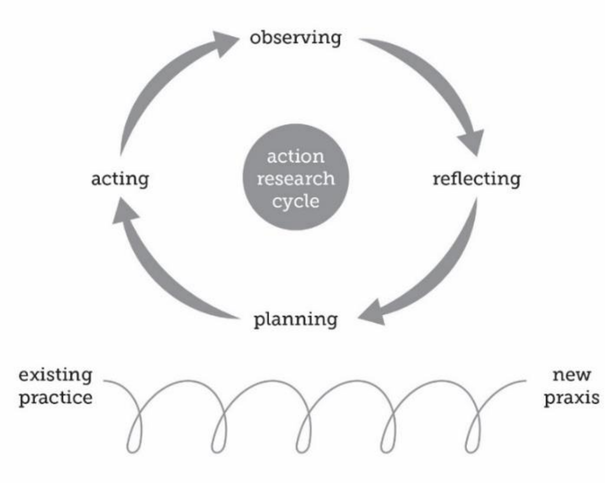

Figure 14. Action Research Cycle (Adapted from McNiff & Whitehead, 2006).

Action research is a method to transform the existing practice through instilling theoretical knowledge towards a new praxis. Yet for the design theory, the practice is never detached from theory. Design research either is steered towards informing the practice by providing data, considerations and inspirations for it, or aims to understand the changes in the context of the practice and present directions for it. Yet, in order to detach ourselves from the existing contexts and produce longer lasting directions – like in the case of research for sustainability and sustainable design – the practice and theory both need to be taken into account and transform them concurrently. As emphasized by Gaver (2012), *research through designing* presents potentials in developing new design theories and manifesting their desirability and practicality in the future of practice. Gaver (2012) differentiates theories developed with research through design from scientific theories, because the criterion for 'falsifiability' – an endless number of confirmations does not prove a theory, yet one incompatible result can disprove it (Popper, 1963) – does not apply to design theories. The aim of research through designing is not to create theories that are never wrong, yet it is about showing what is possible (Gaver, 2012), and in the case for sustainability and sustainable design, it is about "presenting new perspectives on the potential and possibilities for a more sustainable material culture" (Walker, 2011, p.27). Design theories present themselves through annotated design explorations that embody the theories themselves. As the number of explorations increase, they form what Gaver (2012) calls "annotated portfolios", and the theoretical ground expands to inspire and inform the design practice. Figure 2 to 6 in *Section 2.1. Design for Sustainability* are examples of this research approach in design for sustainability literature that reveals new, theoretical directions for sustainable design with their implications explored tangibly.

3.1.2. Development of Research through Co-designing

As mentioned before, this study aims to explore not only the outcomes of open design, but also its processes which include many collaborators. Participatory action research, which involves the members of a community, who are affected by certain questions and issues, addresses those concerns and issues as co-researchers (Reason & Bradbury, 2008). The participation of people is of upmost importance to initiate change within the communities, and this method is used for wide ranging purposes like sustainable community development (Gupta, 2006; Vernnoy, 2003; Case, 1990), education (Ennals, 2004; Carr & Kemmis, 1986) and public health (Hills, Mullett & Carroll, 2007; Eisenberg, Baglia & Pynes, 2006). Participatory design is similar in this sense, since it regards people who are affected by the outcomes of design as necessary to take part in the design process (Ehn, 2008). Although participatory design has produced a fair amount of literature with wide-ranging methods and tools, initially it started out as a way to include people affected by the design outcome in its design process through action research (Spinuzzi, 2005). As opposed to traditional research which aims to produce results meaningful beyond the research context, participatory design as action research aims to achieve improvements in participants' lives (Clement & van der Besselaar, 1993). However, in this study, the aim is not to use a participatory method to develop a certain outcome directly beneficial for all the participants. The aim is to explore the opportunities and limitations of different open design processes for product/part longevity. Hence, I needed a different, exploratory approach that can produce knowledge on both open design process and outcomes, and adapted research through designing as follows.

In their literature review on research through design, Godin and Zahedi (2014) points out that most research through design studies discuss 'design praxiology' – study of the practices and processes of design (Cross, 1999) – and suggest that Schön's (1983) reflexive practice as a fitting design praxiology framework for these studies. According to Schön (1983), reflexive practice can present different kinds of contributions, like tools for practitioners to plan and think, commonly adopted ways of communication and series of inspirational solutions and experiences – which is similar to *annotated portfolios* explained by Gaver (2012). Reflexive action can happen in two ways: reflection-in-action and reflection-on-action. Reflection-in-action happens during the practice (i.e. designing) depending on tacit knowledge of the practitioner, while reflection-on-action is done after the practice to reflect on the decisions made (Schön, 1983).

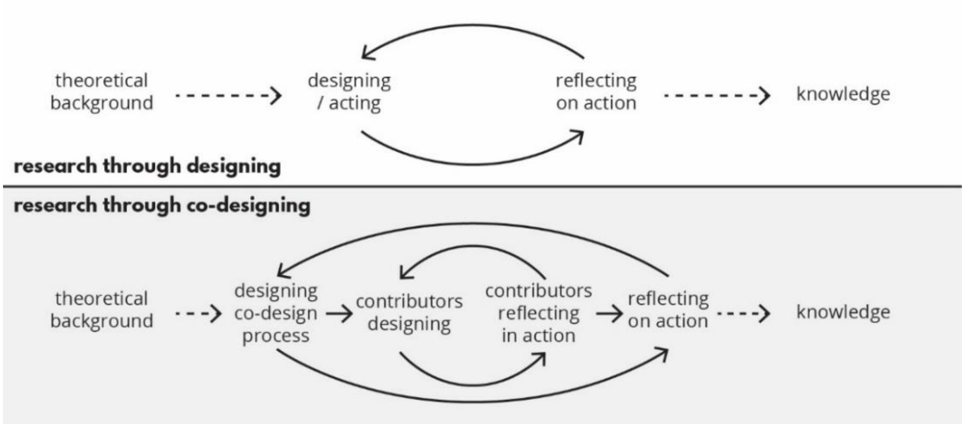

Figure 15. Adapting the steps of research through designing for co-designing processes.

Considering the steps of research through designing – based on the action research cycle in Figure 14 – and the reflexive practice framework developed by Schön (1983), I have developed and adopted the research through co-designing steps in Figure 15. As the researcher/designer of this process, I need to design the co-design process with respect to the aim of this study and the existing literature on it, and provide the contributors with necessary knowledge and tools to explore the concerns of this study. Then, the contributors can design and reflect on those concerns during and after designing. After that, I can reflect on the outcomes of this process as well as the process itself, make necessary changes accordingly for the next stage and finally present the emerging knowledge.

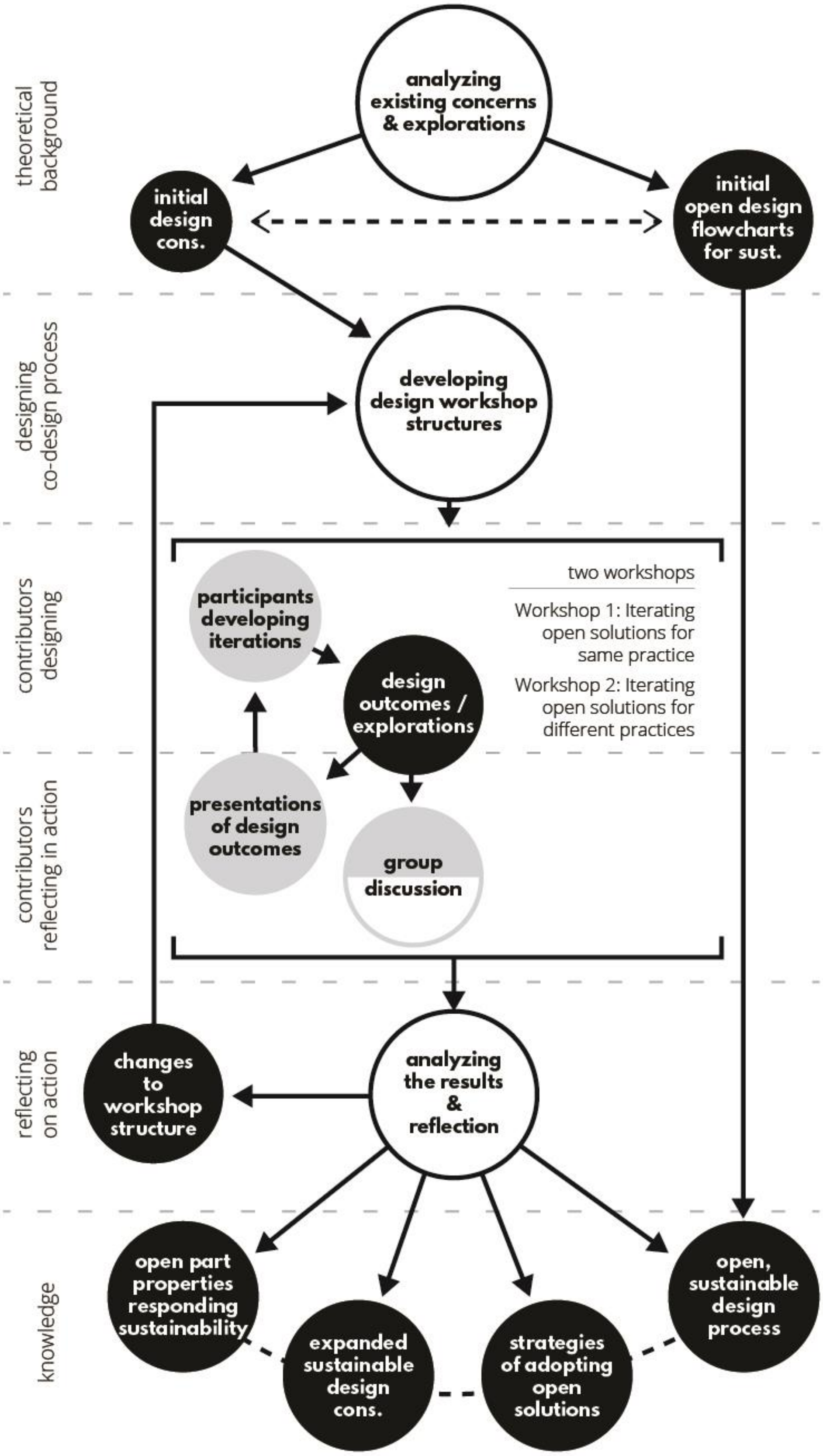

Figure 16. Research through Co-designing steps used in this study.

Figure 16 shows the steps of this study, and it was developed to present how *research through co-designing* was adopted for this PhD study. I started with analyzing existing concerns and explorations in open design and sustainable design areas, and to find out initial open, sustainable design considerations and process flowcharts for design concerns to inform the following stages of the research. After that, I have developed and conducted two open design workshops on personalization and part reuse, which facilitate the conceptual development of open design solutions and their iterations with different sharing patterns (i.e. iterating for the same practice and iterating for different practices). The outcomes of these workshops were open, sustainable design explorations, participant presentations of the design outcomes and group discussions. Through analyzing and reflecting upon these outcomes, I reached at open part properties that would respond to the sustainability concerns of the study, refined design considerations to be included into the idea-generation stage of any open design project on kitchen practices, strategies of adopting open solutions and a flowchart showing how open, sustainable design processes can be handled within the area of small kitchen appliances.

3.1.3. Question of Reliability in Research through Co-designing

Research through designing is different from the research for design or research into design in the sense that the goal of the researched design is the design outcome, but the goal of research through design is the knowledge and understanding (Frayling, 1993). The applicability of the outcomes of research through designing (i.e. design explorations) in real life contexts, or the quality of the design solutions, are of little importance, as the concern of research through designing is not the end product but the knowledge emerging from the design process and embedded in the design outcome. However, this also brings forth the question of reliability of the outcomes, since none of the results can be validated through replication by any other design researcher, even though s/he is presented with the same design problem and problem framing (Zimmerman *et al*., 2007).

In qualitative research, the question of reliability is discussed under its procedural properties: the recording and documentation of data through detailed and conventional ways in ethnography (Silverman, 2001; Kirk & Miller, 1986), or the detailed interview schedules and training of interviewers, followed by detailed recording and transcription of data in interviews (Flick, 2006). In action research, the reliability of the study is assessed through detailed documentation and objective presentation of the process as well as the results. This is called the *recoverability* criterion and enables anyone to recover each and every step of action research and subject it to critical scrutiny (McNiff, 2013). This criterion is also suitable for research through designing, enabling anyone to follow through the chain of reasoning and to assess the decisions made by the researcher in the context of the research problem at hand (Biggs & Büchler, 2007). To enable the *recoverability* of research through designing process, Pedgley (2007) suggests presenting the process in chronological order, in a clear and focused manner, through documented images of the process.

However, this study adopts a different framework (i.e. research through co-designing), in which the researcher/designer builds the structure in which the contributors (i.e. workshop participants) carry out the designing. While recoverability is an important aspect with regards to the question of reliability, this study also requires a way for the researcher/designer to identify contributors' views through systematic documentation of their discourse as well as their design work. Only through such an approach, researcher/designer can analyze and reflect on the design outcomes properly. In this study, the presentations of design outcomes and group discussions shown in Figure 16 were developed and integrated into the methodology for this purpose. Presentations and group discussions, along with the design outcomes were recorded and in a systematic manner, and the tools used for this purpose are explained in the following sections.

3.1.4. Focus of the Study: Kitchen Practices Shaped around Small Kitchen Appliances

In *Section 1.1. Significance of the Topic* , one potential for open design is presented as rethinking and transforming already established product categories and practices shaped around them, and offering alternative ways of producing and using them for sustainable production and consumption. Kitchen practices shaped around small kitchen appliances fits into this category for two reasons:

1. their growing acceptance in the domestic environments;
2. their relatively short life spans.

Thinking about the number of small kitchen appliances owned and used by people, one can easily observe the growing space small kitchen appliances take up in the kitchen. Global market researches show that this product category grows through diversification of products according to more specific uses and consumer segments (Euromonitor International, 2014; GfK, 2014). The examples of this diversification can be seen in your local appliance stores with examples of very specific types of appliances (e.g. waffle makers, soup makers, egg cookers, etc.). This diversification of product types is, of course, visible in our kitchen environment as well, which is now filled with similar yet not the same hybrid products that include the exact same parts repeatedly used in different shells.

While small kitchen appliances are getting more diversified and more accepted into the everyday life, and practices begin to be shaped around them, this product category has shorter projected lifespans. For example, the legal life-spans of small kitchen appliances are around seven years, as opposed to other household electrical products (i.e. white goods) whose legal life-spans are 10 years (Turkish Republic Ministry of Industry, 2003). Furthermore, users may be reluctant to purchase products with longer lifespans, as they are more expensive and can become outdated (Mackenzie *et al*., 2010; Cooper & Mayers, 2000). Also, many small appliances are discarded even though they are still functioning (Cooper & Mayers, 2000).

Due to the above-mentioned reasons, I decided to focus on small kitchen appliances and practices shaped around them for this study. This focus was also useful for facilitating the workshops, as every participant had use experience with small kitchen appliances in their daily lives and they were able to reflect on their practices to develop alternative ways of carrying out those practices, responding to their own needs and preferences. In the following sections, the methods and tools used within *research through co-designing* framework to explore open, sustainable design process for practices shaped around small kitchen appliances will be presented.

3.2. Analyzing Existing Concerns and Explorations

This study aims to explore the potentials of open design for sustainability through *focusing on small kitchen appliances and practices shaped around them*, and in order to understand in what ways an open design process should develop and how people can contribute to it, design explorations and design research that promote openness and/or product/part longevity in kitchen appliances and kitchen behaviors are analyzed in this study. The explorations, research projects and online platforms were selected due to their focus on kitchen practices and appliances. The examples provide different kinds of data (e.g. design considerations for idea-generation, complete design ideas, take-back system designs, etc.), which is normally hard to analyze together. In order to produce meaningful input for the next step of the study (i.e. design workshops), the content analysis method is utilized. Content analysis is a commonly used method in analyzing both qualitative and quantitative data and is described as the "intellectual process of categorizing qualitative textual data into clusters of similar entities or conceptual categories to identify consistent patterns and relationships between variables and themes" (Julien, 2008, p. 120). Through content analysis, data collected using various mediums (e.g. interview transcripts, reports, design explorations, newspapers, drawings, photographs, video recordings) can be analyzed. There are two approaches on content analysis: deductive and inductive. The deductive approach assumes codes or categories derived from pre-existing theories or concepts, and analyzes the data set in a quantitative fashion. On the other hand, the inductive approach - i.e. qualitative content analysis - is about detailed reading of the data and revealing the contextual content within. It is useful in the sense that both conscious and unconscious messages in the data can be identified and presented. In this research, the inductive approach is adopted to explore the contextual content (e.g. reasoning behind design solutions, their relations to sustainability concerns of the study, insights on open design process, etc.), and the existing literature on small kitchen appliances and behaviors around them (e.g. reports, articles, manifestos, etc.) and available open and/or sustainable design explorations/applications are analyzed.

3.2.1. The Analysis Table

For this analysis to be useful in the further stages (i.e. workshops and design explorations), initially the design problems mentioned in the data and the parts that are needed to be addressed during the open, sustainable design process were coded. The parts were coded according to the problem definition, which ranges from very general codes like interior surfaces – which infers to all surfaces that come into contact with ingredients – to very specific codes like motor, switch, etc. – which only infers to a specific kind of part. These codes are helpful to understand the problem definition in question by linking it to design, production and post-use of parts with respect to sustainability.

Considering the varying skills, knowledge and experience of the contributors in open, sustainable design processes, what each contributor can and/or will do throughout the design process (as discussed in *Section 2.2.1.2. Processes*) and the varying levels of contribution s/he can provide happens on a very large range. An individual may only partake in the dissemination of open knowledge, while another individual can create the shareable knowledge. Also, any shared knowledge is subject to change through people's contributions, expanding the solution ground for open, sustainable design. For the purposes of this analysis, I grouped these different kinds of contributions as: (1) creating, (2) sharing, (3) implementing, and (4) adapting. These are indicators for understanding how the design-related information is created, developed and conveyed between people in an open, sustainable design process.

1. *Creating* refers to the generation of new design solutions and new design-related data and knowledge that can be shared. The nature of the created solutions or knowledge varies from specific instances like, CAD data, blueprints, etc. to more general forms like, guidelines, considerations, etc.
2. *Sharing* refers to the dissemination of open data, knowledge and opportunities among people through various channels, like Web 2.0, wikis and open platforms, workshops and other forms of sharing skills, maker spaces and open hardware.

3. *Implementing* refers to the usage of open knowledge by an individual without altering it. This may include using shared design data to produce a designed object, or following repair manuals.
4. *Adapting* refers to the altering of open knowledge to better fit the needs and preferences of the individual. It includes the understanding of shared open knowledge and exploring the opportunities of the created knowledge/data. Exploring different part assemblages with shared parts designs or finding easier ways to repair products.

The design problems, related parts and the way they are created/shared/adapted were then coded with sustainability concerns they represent. The sustainability concerns found during the analysis of existing concerns and explorations, which are related to the concerns of this PhD study, are:

- product/part longevity
- personalization
- part reuse
- distributed production
- ease of maintenance
- ease of repair
- ease of upgrading

These general sustainability concerns were useful in developing, defining and grouping the design considerations throughout the content analysis. The design considerations (which are explained in *Section 4.2. Emerging Considerations for Open, Sustainable Design Process of Kitchen Practices* later) were developed and defined during the analysis, taking into account the design problems, the sustainability concerns and the life-cycle phase they are affecting. In return, a better understanding on how to respond to these sustainability concerns throughout the phases of open, sustainable design process (i.e. designing open parts, locally or individually producing, using, maintaining, repairing, reusing) was acquired. The details of how this coding helped to produce results are explained in further stages.

Table 6. Partial from the analysis table for existing literature and design explorations of small kitchen appliances and behaviors, focusing on informing assembly consideration.

Source	Design Problem	Implicated parts	Related life-cycle phase	Create/Share/Adapt	Sustainability concern	Design Consideration
Considerations for Small Kitchen Appliances by Sustain! DRL	All parts can be replaced individually, preventing the disposal of functional parts	All Parts	Post-use	Sharing: Ways of removing and replacing any part should be shared Implement: Shared ways of removing and replacing should be implemented to prevent damaging other parts Creating: Easy to follow and apply knowledge about disassembling, replacing, repairing and assembling any part should be created	Ease of repair, Part Longevity	Informing disassembly, Informing Repair, Informing assembly
	Parts could be used in different combinations, allowing easy part replacement, upgrading and reuse	All parts, Connection details	Design	Adapting: Adapt the product according to needs and preferences through reusing parts and upgrading Creating: Design parts according to shared design rules, limitations, etc. and ways they can be assembled in different combinations Creating: Explore opportunities created by standard connection details and transform them into sharable form	Ease of repair, Part Reuse	Standardizing assembly details, Informing assembly
	The size of the container, kinds of scaling, motor power, adjusting the power, etc. should be responding to the different and changing needs of peoples	All parts	Production	Sharing: Possible ways of bringing together parts and products according to needs and preferences, in a way that is easy to understand Creating: Sharable knowledge on bringing together different parts should be created	Personalization	Informing assembly
	Perception of durability, especially for assembly details, is important. As people tend to be careful to parts during use, maintenance and repair.	Container, handle	Production	Sharing: Knowledge on aspects of assembly that affect the strength of that assembly should be shared Adapting: This knowledge should be assessed according to the parts at hand and practices to be performed Creating: Sharable knowledge with details on aspects that affect the strength of assembly	Part longevity	Informing assembly,
Re-done appliances by Re-do studio	Instead of discarding, working components (i.e. switches, resistance, electrical cards, etc.) should be reused through bringing them together in different assemblies	Heating elements, Switches, Electronic boards	Design	Sharing: Share design data of the structural components so that people can also use them Creating: Design structural components that can house used, standard components	Part reuse	Standardizing assembly details, informing assembly
OS Water Boiler by Jesse Howard	Bringing together standard parts with designed parts, through standard assembly details	All parts	Production	Sharing: Ways of producing parts to bring together with standard parts Creating: Knowledge on alternative ways of producing and bringing together parts	Distributed Production	Local Skills for Production, Informing assembly

Following upon the above-explained thought process, an analysis table (Table 6) was prepared with 6 coding columns: (1) addressed problems in kitchen appliances and environments, (2) object parts that are implicated by these problems, (3) related product life-cycle phases, (4) create/share/adapt steps for an open, sustainable design process for kitchen behaviors, (5) general sustainability concerns about the problems, and (6) design considerations regarding these problems.

Table 6 shows a part of the analysis table focusing on *informing assembly* consideration, to present how data is analyzed to develop considerations, and how this analysis led to the outcomes explained in the following sections. For example, the data of TÜBİTAK project, Re-done appliances and OS Water Boiler indicates that informing assembly details is important for ease of repair, part reuse, personalization, part longevity and distributed production. The consideration affects all the parts in some cases, while it affects specific parts (i.e. container, handle, heating elements, switches, electronic boards) in others. All these cases present different kinds of knowledge to be created, shared and adapted in an open process, which are broken down in the related column. The way open knowledge is created, shared and adapted can be solely focused on *informing assembly* consideration, or it can include other considerations (i.e. informing disassembly, informing repair, standardizing assembly details, local skills for production). All the analysis is filtered according to considerations to define their implications within an open design process, or according to sustainability concerns to understand how, and in which stages, the considerations affect these concerns. This filtering allowed me to develop the flowcharts which are explained in the following section.

3.2.2. Outcomes for Further Stages: Flowcharts of Design Considerations and Concerns

This analysis is designed to aid me throughout the following stage of this study (i.e. design explorations) by providing me with the design considerations in the context of product/object lifecycles to develop and assess open, sustainable design processes for kitchen appliances *during research through co-designing*. As an outcome of this analysis flowcharts for general open, sustainable design concerns for product/part longevity, personalization and post-use were developed in open design scenarios.

Considerations that emerged through this analysis were depicted with self-contained flowcharts (Figure 17).

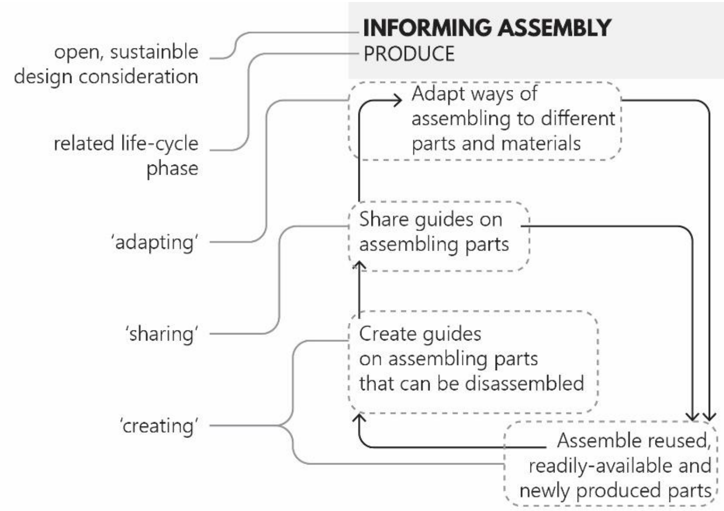

Figure 17. An example of consideration flowcharts for 'informing assembly'.

The kinds of contributions coded enabled the basic structure of the flowchart necessary for the considerations, and these were detailed as an accumulative result of the analyzed data. Each consideration is inclusive of the analyzed explorations or concerns, and they are explained in *Section 4.2. Emerging Considerations for Open, Sustainable Design Process of Kitchen Practices.* These considerations play crucial roles within the open, sustainable processes, and are indicated with the product life-cycle phase they affect and the necessary steps for the openness of design knowledge.

It should be noted here that these cards were developed according to the analysis of existing concerns and explorations, and their content may be limited in their current state. These flowcharts embody three different kinds of scenarios regarding the consideration in question for open, sustainable design processes:

1. *Creating and sharing new design-related knowledge*: In this scenario, new design-related knowledge (e.g. CAD data, assembling guide, repair manual, etc.) is created and applied by a person and then this information is shared to be openly used by other people. This requires two steps of 'creating': Firstly, new knowledge (e.g. ways of assembling some parts)

should be created, and then, it should be transformed into a sharable form (e.g. creating a step-by-step guide for assembling parts).

2. *Adapting shared design-related knowledge:* This scenario is about building upon existing, shared knowledge through changing and/or developing further according the one's needs and preferences. Shared knowledge (e.g. CAD data, assembling guide, repair manual, etc.) is adapted to the design process at hand (e.g. tinkering with the CAD data, using a different method other than the suggested one while assembling, etc.). Then, the adaptation should be added to existing design-related knowledge, developing it further.
3. *Implementing shared design-related knowledge:* This scenario refers to utilizing shared design-related knowledge (e.g. CAD data, assembling guide, repair manual, etc.) without modifying it. This scenario is important, as it is crucial for the dissemination of open, sustainable design solutions and processes.

These scenarios are depicted in the consideration flowcharts (Figure 17, above) for each open, sustainable design consideration and they are brought together in process-based sustainability concerns flowcharts according to the life-cycle phase they are related to. The considerations related to design and production of parts were placed before the parts, considerations related to bringing parts together are placed after the parts and before the open solutions. The considerations affecting the post-use processes directly are placed after the open solution. A simplified example of these flowcharts can be found in Figure 18 below.

These flowcharts enabled me to understand how open design process for sustainability can happen through understanding how considerations are useful throughout the process. They also helped me analyze the outcomes of the design workshops in further stages by providing me a structure to build upon.

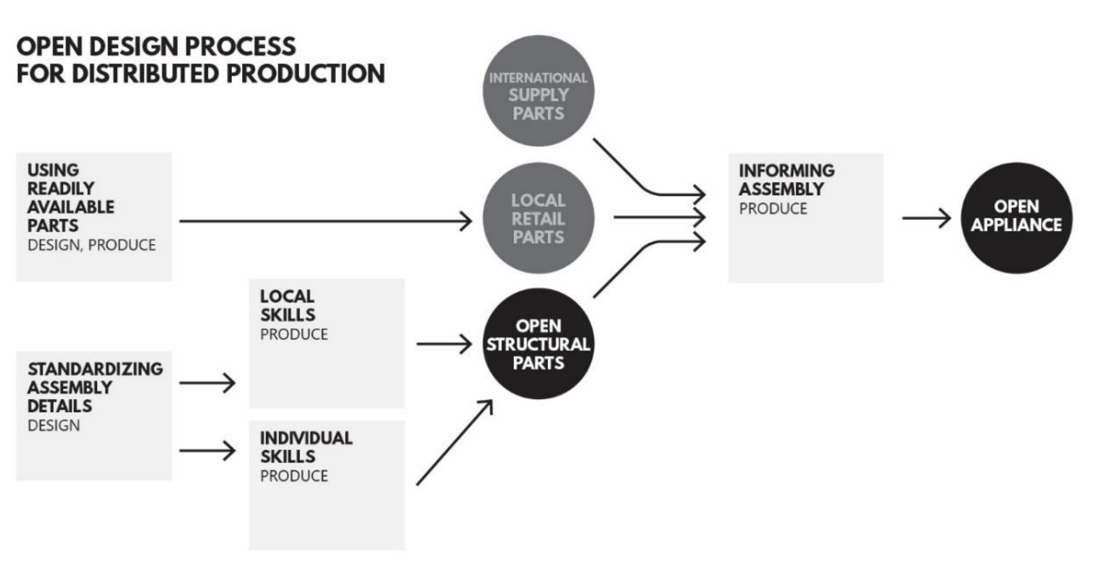

Figure 18. A simplified process-based sustainability concern flowchart based on distributed production.

3.3. Design workshops

Design workshops are generative sessions to explore design ideas and solutions with designers and non-designers. During the sessions, projective generative tools and techniques are generally utilized to initiate and help facilitate the exploration of design possibilities within the scope of an assigned topic (Martin & Hanington, 2012). Throughout the sessions, the participants share their insights on the assigned topic, assess others' insights and produce outcomes to reflect them. The outcomes of the data are qualitative in nature and generalizable results cannot be drawn from them, as the number of people attending the workshops are limited.

During design workshops, different generative tools and techniques (e.g. collages, diaries and mind-map) are presented to the participants according to the expected outcomes from the workshop. There are two kinds of generative tools and techniques: projective and constructive (Hanington, 2007). Projective tools and techniques aim to encourage people to explain their thoughts and experiences in detail. The examples of these tools and techniques include diaries, text- or image-based cards and their sorting, and daily logs. Constructive tools and techniques aim to enable people to make tangible things that represent their thoughts and experiences, and include Velcro modelling, collages and mind-mapping (Martin & Hanington, 2012). Various combinations of these tools and techniques can be selected to enable the development of outcomes most suitable to the purposes of this PhD study.

3.3.1. Design Workshop as a Tool for Research through Co-designing

Design workshops can be used for various reasons. They can be used for user research purposes, to gather insights and ideas about an assigned topic, to produce different kinds of outcomes to reflect on those insights (Martin & Hanington, 2012, p. 62). The *outcomes* can be analyzed to uncover participants' perspectives on the assigned topic. They can also be used for educational purposes, to enable participants to learn and experience certain methods, tools or concepts (Turgut & Cantürk, 2015; Pretty *et al.*, 1995). In this case, some *learning outcomes* are set and they are assessed by the knowledge gained by participants. However, the goal of this study is to explore the *open design process*, how the *process* and *its outcomes* can respond to sustainability concerns of the study.

Open design is a process of continuous designing and redesigning process, with contributors from different backgrounds and their different kinds of contributions, not with purpose of finalizing a project but with the purpose of expanding the solution ground (see *Section 2.2. Open Design*). For research purposes, exploring the potentials of such a process through individually experiencing it – as it would have happened in research through designing – is not only demanding, but also unfruitful, as open design process requires different contributors iterating an initial solution through their own perspectives. The characteristics of an open design process (i.e. different contributors through different contributions, designing, sharing and redesigning) needs to be replicated – or at least emulated – for more grounded discussions and physical outcomes. Hence, the workshops aim to understand how open, sustainable design solutions develop through sharing conceptual designs of parts and their assemblages in the form of products, by mainly focusing on the design phase, and through emulating an open design sharing environment in the form of a workshop.

With such an emphasis on open design process focused in this study (see *Section 2.3. Open Design Process for Product/Part Longevity, Personalization and Post-use*), an initial open solution developed by a (group of) contributor(s) needs to be iterated by other(s), resulting in at least three iterations (i.e. initial solution, 2nd iteration and 3rd iteration) to observe and explore the potentials of the process and its outcomes. The contributors need to be introduced to the knowledge generated in the previous phase of this study (*will be presented in* Chapter 4. Analyzing Existing Concerns and Explorations), and also need to reflect on the open solutions they create through this knowledge (i.e. reflection-in-action). Hence, the workshop structure in Figure 19 was formulated.

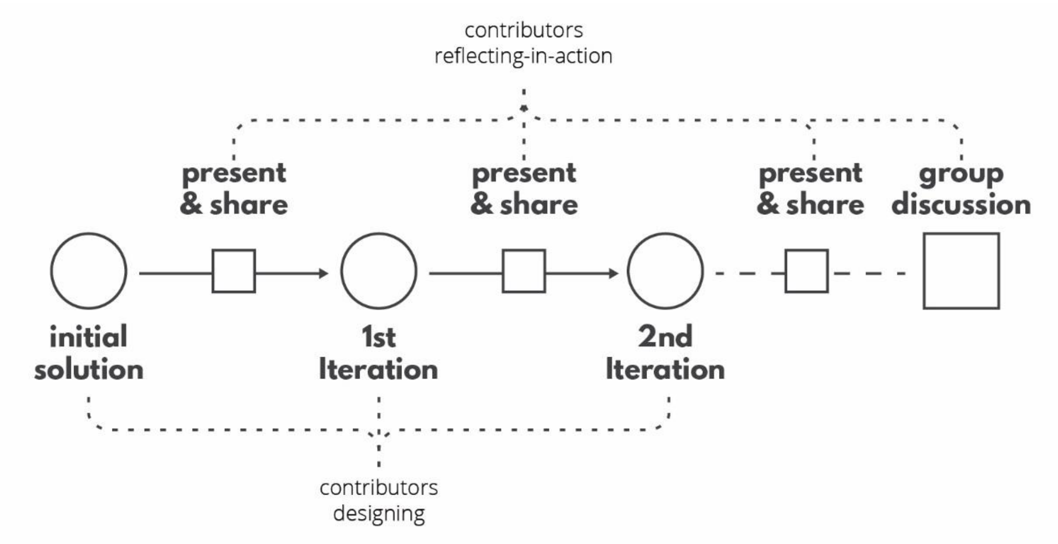

Figure 19. The rough structure of design workshops conducted during this PhD study.

Conducting a workshop should be planned rigorously, considering a wide range of factors. Chambers (2002) provides a checklist of 21 elements that need to be reflected upon while preparing a participatory workshop in general, important ones of which are presented below along with their implications in the context of this PhD study:

- *Purpose*: Emulating the open design process to find out its implications for product/part longevity, with a focus on personalization, maintenance, repair and part reuse, for kitchen practices shaped around small kitchen appliances.
- *Participants and their possible expectations:* Following the open paradigm, the workshops are open to all who are interested in the topic. However, due to the topic, the participants would be limited to designers and engineers

who are already familiar with open design, or who want to learn more about it. These participants would be interested in learning more about the sustainability aspect and how open design can respond to it.

- *Method of participating:* The participants are expected to develop open design solutions for kitchen practices, share them with other participants, then adopt and develop other participants' open solutions.
- *Role of the facilitator:* The facilitator is the designer/researcher who designs this workshop process, guides participants throughout the process, documents the outcomes of the workshop and reflects on those outcomes for research purposes.
- *Setting:* The large space with large tables to work on and build mock-ups, and presentation areas to share open design solution are necessary. The space needs to be well illuminated for documenting purposes with cameras.
- *Time and planning:* Each workshop should be conducted within a day, to ensure potential participants attendance to it. The stages of the workshop should be planned in detail, while leaving some room for potential delays in each stage.
- *Materials and equipment:* Projective generative tools will be used (e.g. cards, timelines) to inform idea-generation and constructive generative tools (e.g. toolkits) to enable building tangible 3D outcomes will be prepared. In addition, a sharing medium to share open solutions (e.g. posters) will be used.
- *Outcomes:* The outcomes of the workshop will be physical mock-ups and changes among every iteration, documented in detail. Another outcome will be the participants own reflections on their solutions through presentations and reflections of all the participants about open design process and its implications for sustainability through group discussion.

Although the above-mentioned list provides a rough idea about the content of the design workshops that are conducted during this study, the details on their structure, generative tools developed and outcomes will be presented in the following chapters of each workshop (i.e. *Section 5.1. The Structure of Workshop 1 and Generative Tools* Used and *Section 6.1. The Structure of Workshop 2 and Generative Tools Used*).

Even though public calls were made through different mediums and they were *open to all* (see *Appendix F – Call for Participants to Workshop 1*), the calls aimed at attracting people who were interested in experiencing open design process through designing solutions for kitchen practices. The purpose of the workshop (i.e. emulating open design process for sustainability concerns of the study), the theme (i.e. kitchen practices) and the expectations from participants (e.g. designing solutions and building physical outcomes through generative toolkits) were clearly stated in the calls. The calls were made *open to all*, so that people who did not have a design background could apply for workshop participation, however all the participants of both workshops were from a design background with different levels of education (i.e. Bachelors', Masters' and PhD). Participants' levels of education did not affect the outcomes in an observable manner, however all of them being from a design background certainly eased the facilitation of the workshops as they were quick to generate several design ideas, develop one of those ideas into design concepts and build physical mock-ups with the help of provided generative tools. The list of participants of both workshops and their backgrounds are provided in *Appendix H – List of Workshop Participants*.

3.3.2. Group Discussions

Having experienced an open design process in the workshop, the insights of participants were gathered through facilitating a discussion on different aspects of the workshop and open design for sustainability. This discussion was conducted as a focus group, which are done with a group of participants through facilitating a discussion on topics of interest (Glesne, 2011, p. 131). Focus group aims to unravel individuals' opinions on topics of interest, and uses the interaction among participants to unravel data and insights (Flick, 2006). Focus groups can be used to complement other methods and tools, like getting participants' insights on an earlier study (Morgan, 1988). This is how focus group is used in this study, to gather insights on the participants' workshop experience. Hence, the discussion revolved around the following topics:

- The process of designing: Reflecting upon designing parts and part-assemblages according to participants' own needs and preferences and the concerns for sustainability. The structure of the workshop, generative design toolkit and other tools are also discussed.
- The process of sharing: Reflecting upon sharing of part designs and assemblages, and adapting them to their own needs and preferences. Their thoughts and insights on using parts for different purposes in different iterations or practices are asked as well.
- The potentials for sustainability concerns of the study: Discussing how such sharing of part designs and assemblages affect the part longevity, personalization and post-use processes.

These focus group discussions situated at the end of the workshops are important for *research through co-designing*, as it – along with the design solution presentations – produces data about contributors' reflection-in-action. This is still regarded as reflection-in-action, as the participants do not have the chance to go through all the process and reflect on the collective data revealed during the workshop. The outcomes of the groups discussion help me to understand and reflect on how they design and redesign at every stage, and if and how they perceive the relation between open design and sustainability. The purpose of these discussions is to help me for clarification and ensure the analysis of the workshop processes, outcomes and reflections are done correctly through these insights.

3.3.3. Analysis of the Workshop Outcomes

The expected outcomes of the workshops are design solutions that are developed by and shared among participants through further development and/or alteration of an initial idea into 2^{nd} and 3^{rd} iterations. During these workshops, since they aim to emulate the open design process, an initial solution needs to be iterated by people different from the initial person who designed it. Hence, their analysis need to include a storied approach, which takes into account the changes, happened among iterations to present the implications of open design process for sustainability.

Similar to the previous stage of the study (i.e. Analyzing Existing Concerns and Explorations), content analysis (Julien, 2008) is used while analyzing the outcomes of the workshops. The developed iterations were analyzed *individually* to understand the open, sustainable design considerations and their physical manifestations in the form of open part properties. Open part properties emerged throughout the analysis and they define the specific properties of parts responding to the sustainable design considerations. This analysis allowed me to explore different ways of responding to the considerations to develop open, sustainable design solutions. The relations between open, sustainable design considerations and open part properties are explained as stated by the participants, followed by my reflections on the overall design process and solutions with regards to the sustainability concerns of the study.

In addition, the initial solutions and their 2^{nd} and 3^{rd} iterations are analyzed *sequentially* to find out changing open parts among iterations, and how the way these changes are made considering the sustainability concerns of the study (i.e. product/part longevity, personalization, maintenance, repair, reuse). This is especially useful for the *research through co-designing* method adopted in this study, as looking at how these parts are changed throughout the process enabled me to explore the opportunities and limitations of both open design *process* and its *outcomes*. This analysis brought forward strategies of adopting open solutions, revealed their opportunities and limitations for the sustainability concerns of the study, and provided me with the data to develop open, sustainable design flowcharts presented at the end of *Chapter 5* and *Chapter 6.*

3.4. Remarks on Methodology Chapter

Research through co-designing was developed over the course of this thesis, while searching for a way to explore the potentials of a continuous co-design process like open design. It developed incrementally, through facing the drawbacks of adopting any other action research approach in literature due to their focus on a single designer/researcher and a process leading to an outcome. Research through co-designing involves many contributors in addition to designer/researcher and regards the process as an outcome too.

This also affected the whole structure of the thesis, as the following chapters will include other methodological details that are not mentioned in this chapter. *Chapter 4. Analyzing Existing Concerns and Explorations* will focus on the practices shaped around kitchen appliances by initially presenting the data found for the analysis and the reasons they were selected, and then the results drawn through their analysis in the form of considerations and concerns. *Chapter 5. Workshop 1: Iterating Open Solutions for Same Practice* will start with the detailed account of workshop structure, sampling, generative tools, and continue with the narrative analysis and its results on redesigning for same practices. *Chapter 6. Workshop 2: Iterating Open Solutions for Different Practices* will first present the necessary changes to the workshop structure to explore a different kind of open design process, and then draw results from its narrative analysis.

CHAPTER 4

ANALYZING EXISTING CONCERNS AND EXPLORATIONS

This chapter presents the outcomes of analyzing existing concerns and design explorations on open design and design for sustainability in small kitchen appliances. In the methodology adopted for this study, this chapter is complementary to the theoretical background and the outcomes are developed in the form of design considerations – to be later included in the following design workshops – and open design processes – to provide a starting point for developing a guideline for open design process for sustainability. As mentioned before, the implications of open design for sustainability are seldom explored directly (e.g. OS water boiler and integrated scales) and the themes of design for sustainability, like product/part longevity, post-use and personalization, remain unexplored in the context of open design. The focus on small kitchen appliances further narrows the list to the data as follows:

1. A government founded project on ‘Developing Design Considerations Electrical Household Appliances for Product Repair and Maintenance, and Effective Use of Resources’ (i.e. TÜBİTAK Project No: 112M228) *by Sustain! Design Research Lab, Turkey*.
2. Re-done Appliances project *by Re-Do Studios, UK.*
3. Open Structures Water Boiler by *Jesse Howard, the Netherlands.*
4. Hacking Households, *by Leonardo Amico, Thibault Brevet, Jesse Howard, and Tilen Sepic, the Netherlands.*
5. iFixit.com Online Repair Community pages on Household Appliances.
6. Open E-components *by Weilun Tang, the Netherlands*.
7. I love OS project *by Thomas Billas, Belgium*.

These explorations, research project and online platforms were selected due to their focus on kitchen practices and appliances. I know the research project by *Sustain!DRL*, since I took part in it as a researcher between 2013-2015, from the initial literature to the data collection and analysis. The open design explorations were found through searching online forums and platform like Instructables (instructables.com), OpenStructures Blog (blog.openstructures.com) and P2P Foundation Wikis (p2pfoundation.com) during 2015-2016 Spring semester. Small kitchen appliances in general, and specific names for different kitchen appliance (e.g. blender, kettle, coffee maker, etc.) were used as search keywords. These examples provided me with a rich combination of data, through which I could develop considerations and processes, which are meaningful for the purposes of this study. As they are experimental projects, there are no recent updates on these projects at the time of this thesis submission. In the next section, the examples and why they are selected for this analysis will be introduced briefly.

4.1. Scope of the analysis

4.1.1. 'Developing Design Considerations for Electrical Household Appliances for Product Repair and Maintenance, and Effective Use of Resources' Project

In Sustain Design Research Lab, which I am a part of as a researcher, a three-year research project on developing design considerations on the themes of effective use of resources, product maintenance and repair have been completed in December 2015 (Doğan, 2015). The goal of the project was to develop sustainable design considerations through semi-structured interviews with designers and producers of this product group and generative design research sessions with users. The developed design considerations aim to help designers and producers re-think this product group with respect to sustainable design in an understandable and descriptive way. Throughout the project, the idea for this PhD study – exploring open, sustainable design possibilities of rethinking small kitchen appliances and behaviors shaped around them – emerged and the outcomes of the project were considered to aid me with their detailed analysis of this product group with respect to sustainability.

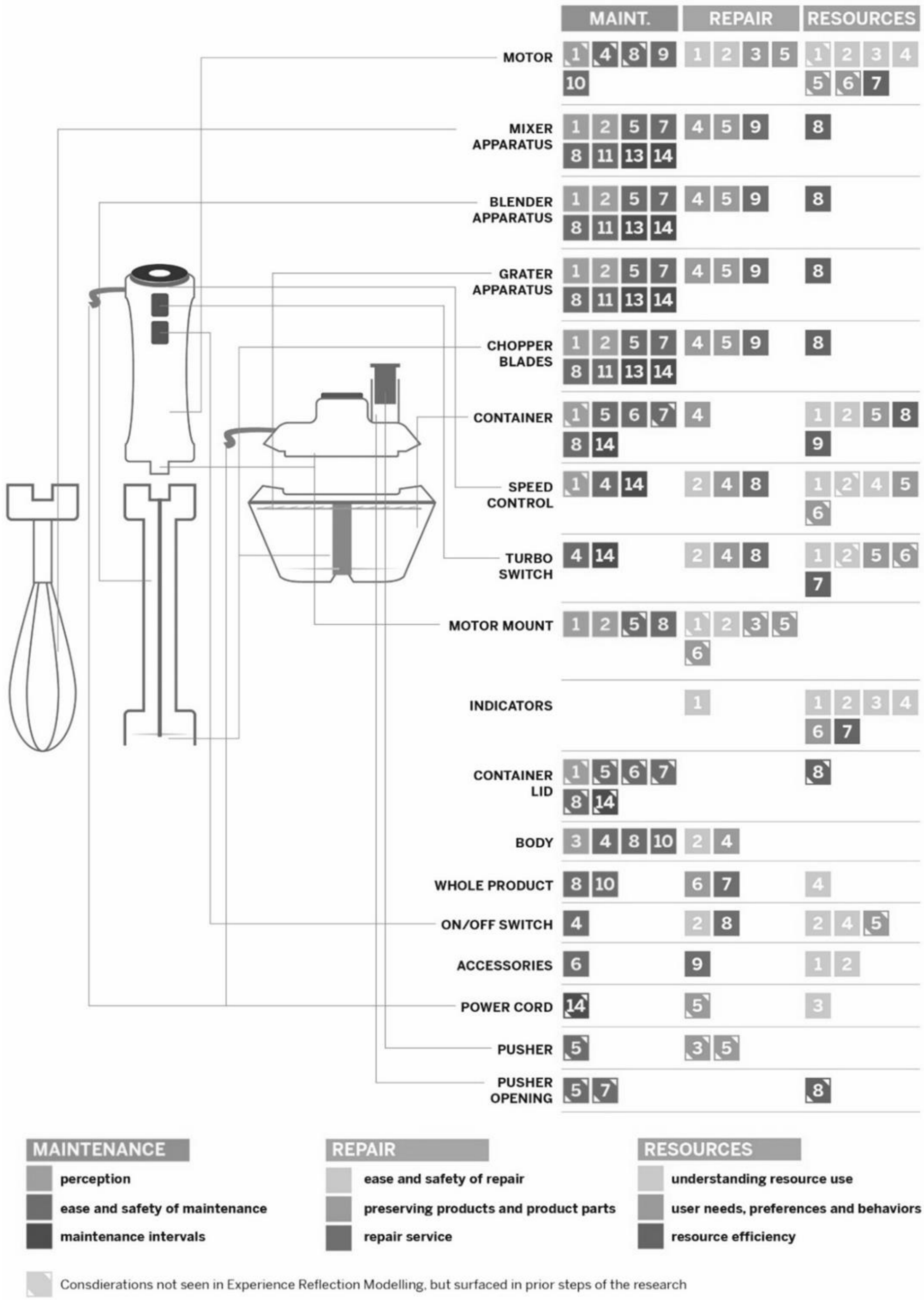

Figure 20. Visualization of sustainable design considerations for blenders/choppers in TÜBİTAK project.

As a result of the semi-structured interviews with designers and producers, and Generative Focus groups (GFG) and Experience Reflection Modelling (ERM) sessions with users (Bakırlıoğlu *et al.,* 2016), sustainable design considerations on effective use of resources, product maintenance and repair for small household appliances were developed (see *Appendix A – Sustainable Design Considerations Developed in TÜBİTAK Project).* These considerations were related to products and product parts, like demonstrated in Figure 20 for blender/chopper product group. In this figure, the numbering next to the product parts is related to the sustainable design considerations developed throughout this project (The corresponding consideration for each number can be found in *Appendix A – Sustainable Design Considerations Developed in TÜBİTAK Project).* The considerations are divided according to the sustainability themes focused in this project (i.e. product maintenance, product repair, and effective use of resources), and each theme has sub-categories:

- For product maintenance, the sub-categories are (1) perception, (2) ease and safety of maintenance, and (3) maintenance intervals;
- For product repair, the sub-categories are (1) ease and safety of repair, (2) preserving products and product parts, and (3) repair service;
- For effective use of resources, the sub-categories are (1) understanding resource use, (2) user needs, preferences and behaviors, and (3) resource efficiency.

These outcomes are detailed in the final report of the project with the implications of these considerations for each product group (i.e. vacuum cleaners, blenders/choppers, contact grills, electrical tea makers, and Turkish coffee makers), most problematic parts for maintenance, repair and resource use and the most important considerations for each product group (Doğan, 2015). The outcomes of this research project are invaluable for my PhD studies due to the project's focus on small kitchen appliances and its comprehensive analysis of these products with respect to maintenance and repair. Many of the open, sustainable design considerations that will be presented in this chapter emerged from this project, however, it should be noted that all the considerations of this project are the result of a research study on mass-produced small electrical appliances. Furthermore, the project has a larger scope, as it presents considerations for effective use of resources. Thus, the considerations of this project and how they affect different kinds of small kitchen appliances are recoded for this PhD study, to be included in the open design process. The following considerations solely emerged from this project, which are presented through their implications.

- *Cleanable surfaces* refer to the cleaning of the surfaces of parts and products, which need to be void of unreachable surface details and made out of either non-stick or scrapable materials;
- *Minimizing need for maintenance* refers to preventing accidental spillages or splashes that can occur while carrying out a kitchen practice and reducing the number of parts that need cleaning after the practice is carried out;
- *Feedback on maintenance need* refers to the visibility of the maintenance need and making sure people can understand when parts/products require maintenance to elongate their lifespans;
- *Feedback on breakdown reasons* refers to the indications designed and implemented into parts and products, making it easy to understand which part is broken;
- *Disassembly for maintenance* refers to separating electrical and non-electrical parts so that non-electrical parts can be cleaned easily, and separating non-electrical parts from each other so that normally unreachable surfaces can be cleaned;
- *Informing use* refers to conveying ways of using a part/product to reduce maintenance need (e.g. ways of not spilling ingredients) and to prevent part/product breakdown (e.g. using motors in short intervals instead of using them continuously);
- *Informing maintenance* refers to conveying ways of cleaning various surfaces to prevent wear, parts to disassemble to reach surfaces, and parts to keep away from water to prevent breakdown.

In addition, the following considerations were developed from the conclusions of the TÜBITAK project in combination with other projects analyzed in this chapter. These considerations are presented here the way they are coded in the data that came from that project.

- *Standardizing assembly details* is found in this project as being able to use certain parts (e.g. teapots, mixer apparatus, heating plates of grills) in different products through standardized dimensions and assembly details across different products, so that they can be reused or easily replaced;
- *Ease of disassembly* is found in this project as being able to remove parts individually so that they can repaired and/or replaced when broken;
- *Responding to needs & preferences* is about changing needs and preferences of people on size of containers, ways of scaling ingredients, power output required for different practices, material choices that can affect the taste of the food or drink;
- *Informing assembly* and *informing disassembly* are found in this project to inform people about ways of assembling parts in ways that ensure secure assembly and disassembly of parts, and enable removal of individual parts;
- *Informing repair* refers to conveying ways of understanding breakdown reasons and repairing the broken parts;
- *Informing reuse* refers to conveying ways of understanding compatibility among parts and products.

4.1.2. Re-Done Appliances

Re-done Appliances is a project that was developed by Re-Do Studio, in collaboration with Bright Sparks Initiative, Islington, UK, in 2013. Bright Sparks Initiative is a city-funded organization that repairs and/or repurposes various kinds of household items (Islington City Council, n.d.). The project is about eliminating the disposal of functioning electrical parts through offering a way of reusing these components in different designs, which are the Re-done Appliances (Figure 21).

The appliances are built out of salvaged electrical parts from broken and/or discarded appliances, readily-available standard parts (i.e. chemistry beakers and wine bottles), and newly-produced structural parts made of natural cork (Re-do Studios, n.d.). The design of the structural parts relies on readily-available standard parts due to their "ubiquity and standardized dimensions" (Re-do Studios, n.d.), which enable the designs to be replicated in other places.

Figure 21. Re-done appliances (retrieved on 11.04.2016, from http://www.re-do-studio.com/re-done-appliances.html).

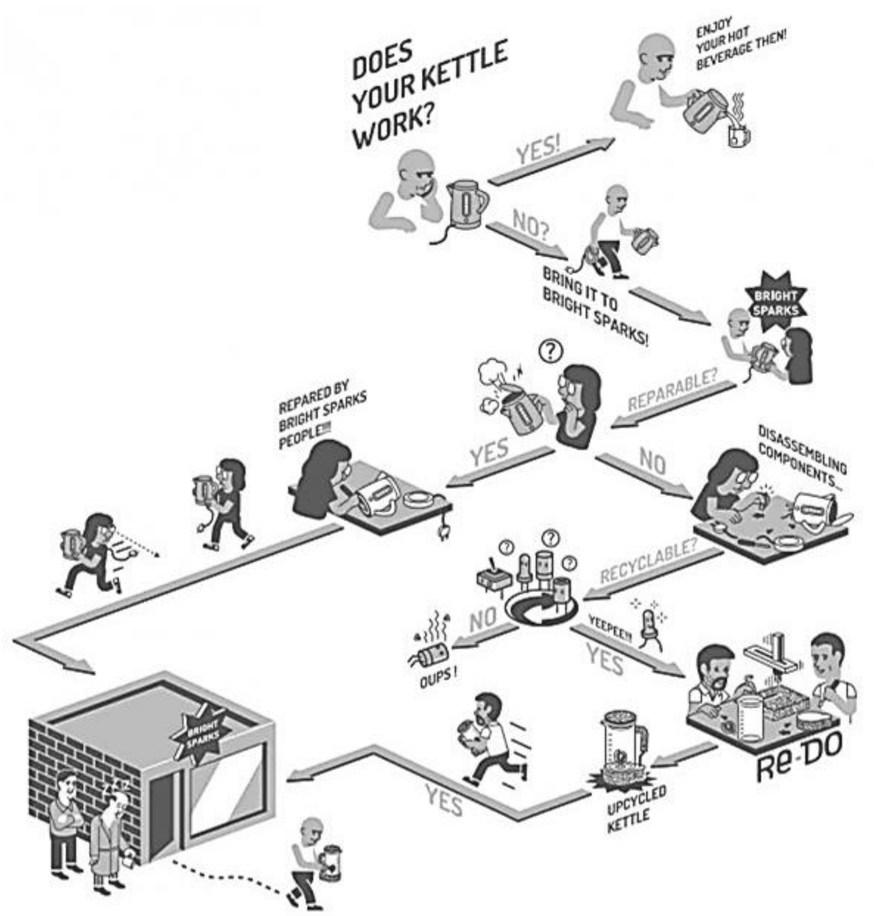

Figure 22. Re-done Appliances Upcycling Flowchart (retrieved on 11.04.2016, from http://www.re-do-studio.com/re-done-appliances.html).

The project's forte lies in the reuse and upcycling system design developed together with Bright Sparks Initiative (Figure 22). Utilizing the local skills of repairmen already employed in the initiative, the broken appliances are either repaired or their parts are disassembled. The disassembled parts are, then, evaluated to understand if they are reusable by experts and reusable parts are reserved. CNC-milling machines are used to produce structural parts out of cork, since these machines do not need craft skills to operate and produce precise results. The parts (reused, newly produced and readily-available) are then assembled into a Re-Done Appliance (Re-do Studios, n.d.).

Several considerations were coded on this project, which are also observed in other projects of this analysis. *Standardizing assembly details* is observed in this project through its reliance on the standardized connection details of the electrical parts to reuse them, and the mass-produced, readily available parts (e.g. beaker) that can be used for various purposes. *Using readily-available parts* is also mentioned as easy to acquire parts that can be replaced easily, if they break down. The reuse and upcycling system in Figure 22 relies on the *local skills* (i.e. repairmen) who can assemble salvaged electrical components and operate digital fabrication tools (i.e. CNC) to produce structural parts out of cork. *Informing reuse* consideration was coded in this project, as people involved in the project need to access knowledge on ways of assessing salvaged electrical parts to decide if they can be reused. *Informing disassembly* is coded as the parts need to be disassembled properly to stay functional and be reused, and *informing assembly* is coded as ways of bringing together electrical parts that are not immediately compatible is necessary.

4.1.3. Open Structures Water Boiler

OS Water Boiler is a kitchen appliance project by Jesse Howard developed in 2012 (Figure 23), which is designed according to the Open Structures modular design grid (openstructures.com, n.d.). Open parts (i.e. body, metal pipe, and bottle housings) are designed according to the modular grid in such a way to house readily-available parts (i.e. bottle, screws, nuts and bolts) and electrical parts (i.e. heating element, switches electric cable). Throughout the designing of open parts, the disassembly and repair of parts and product are considered and assembly details are kept visible (Jesse Howard, n.d.).

Figure 23. OS Water Boiler by Jesse Howard (retrieved on 11.04.2016, from http://www.jessehoward.net/).

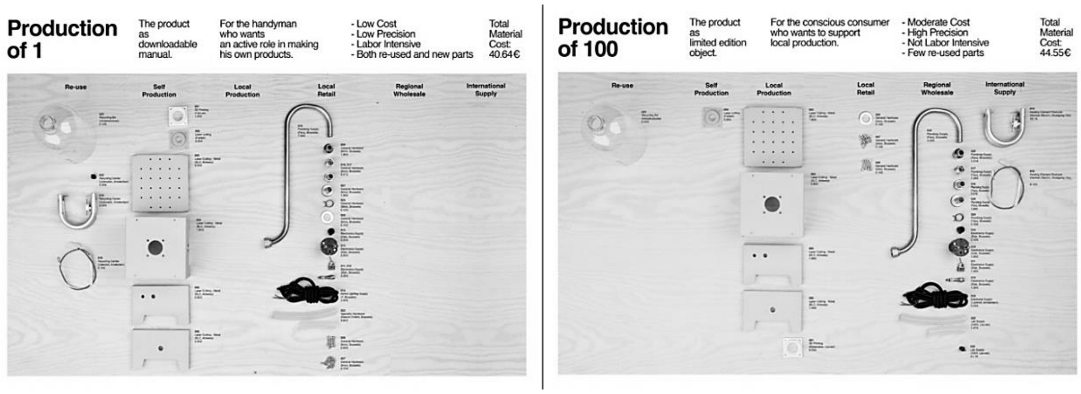

Figure 24. Producing OS Water Boiler on different scales (retrieved on 11.04.2016, from http://www.jessehoward.net/).

The designer aimed at enabling production of the design on different scales (from one-off production to complete mass-production of thousands). In Figure 24, two of such explorations are presented: Production of 1 on the left, and Production of 100 on the right. In production of 1, the product is offered as a downloadable manual and the individual salvages a bottle, a heating element and some cables for reuse. Open parts are produced by the individual and other standard parts are procured through local retailers. In production of 100, the open parts are mainly produced by local producers and new electrical parts are procured through international sales channels. Exploring the possibilities of different production and procurement possibilities are important to understand through which ways parts can be produced and how individuals reach to various types of materials.

Individual skills for production consideration was coded only for this project in the analysis, as some parts (i.e. the product body parts) are designed with simple forms to be easily produced by individuals with minimum machinery (i.e. drills and saw). For producing the design solution in larger amounts, the parts can be produced *local producers* easily and precisely as well. The electrical parts are selected, as they are easy to procure through retail channels and they share *standard assembly details*. *Informing assembly* is coded, as the designer informs the producers about different ways of assembling parts at different scales, as well as ways of bringing electrical parts with standardized assembly details and individually or locally produced body parts together.

4.1.4. Hacking Households

Hacking Households project was developed and presented in 2014 at BIO 50 Biennial of Design in Ljubljana, by Leonardo Amico, Thibault Brevet, Coralie Gourguechon, Jesse Howard, Jure Martinec, Nataša Muševič, Tilen Sepič. The project explored the idea of open programming of objects and aimed to initiate a whole eco-system of programmable objects (P2P Foundation, 2014). The part-object relationship is questioned throughout the project and parts are regarded as flexible and changing. While bringing together various parts in different objects, also the design of the parts is adaptable according to needs and preferences. The project offers flexibility and interchangeability of parts, along with the open sharing of knowledge and data as an alternative to the current inflexible standards of production for home appliances which inhibits the reparability of products and causes waste (Hacking Households, 2014). In Figure 25, different objects (i.e. mixer, heating fan, blender) designed with flexibility and interchangeability of parts kept in mind throughout the project are shown. The structural parts are made of wooden sticks and 3D-printed connectors. The lengths, diameters and materials of the sticks can be changed according to the needs and preferences. The fan blades are depicted as adaptable as well, the shape and number of which can be changed.

Figure 25. Hacking Households project: (left-to-right) open source mixer, heating fan, blender (adapted on 18.04.2016, from http://www.jessehoward.net/, http://sepic.cc/Hacking-Households-1, and http://www.designboom.com/design/hacking-households-bio-50-09-30-2014/).

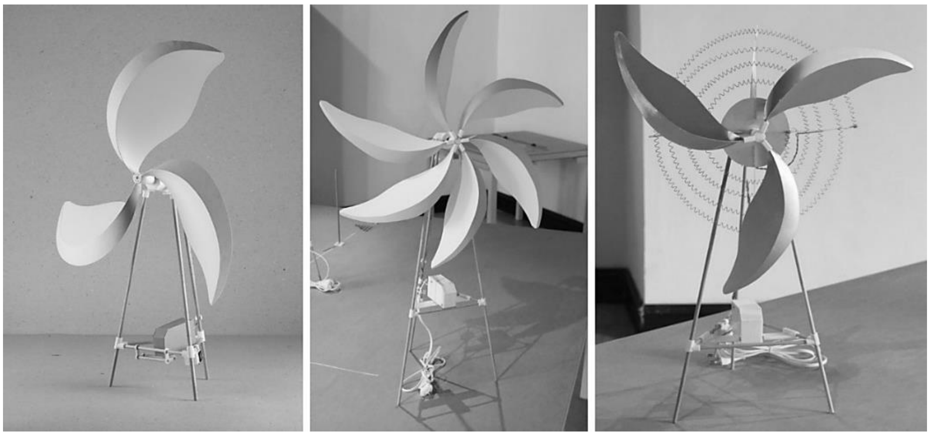

Figure 26. (Left-to-right) Fan with three big blades, Fan with six smaller blades, Fan with three small blades and a heater coil (adapted on 18.04.206, from http://www.designboom.com/design/hacking-households-bio-50-09-30-2014/).

There are standardized parts/modules used throughout the project as well, like motors, wireless modules, switches and cables. These parts can be extracted from one of the designs and can be reused in different objects. The project tries to present the iterative process an open design solution enters, which is especially visible in the iterations of the fan design in Figure 26. The shapes of the blades and the number of them change in every iteration, while the fan design at the right end side, a heater coil was also attached behind the fan, turning it into a heating fan. Due to the openness of parts designs and their assemblages, the designs of objects can adapt to diverse needs and preferences of the individual designing every iteration.

Two considerations were specifically coded for this project. As the project works with the idea of building blocks and standardizes the dimensions of the parts, it also *standardizes the assembly details* through ensuring compatible dimensions. Furthermore, these dimensions can be arranged to accommodate *readily available parts*, like the glass jar used in the blender example in Figure 25.

4.1.5. iFixit.com Online Repair Community Kitchen Appliances Pages

iFixit is an online repair community platform, in which contributors can share repair guides for various kinds of electrical devices (e.g. laptops, phones, kitchen appliances). Inside the platform, there is a dedicated section for kitchen appliances, in which 32 categories of kitchen appliances are listed (iFixit, n.d.). Since this is a user-generated page, the criteria for creating a new category is unknown, yet the page includes blenders, coffee makers, mixers, kettles, toasters and contact grills. Under each category, the repair guides are divided according to brands and models to enable people to navigate through them easily.

The whole platform is built on informing repair and empower individuals to undertake repair processes individually. For example, in Figure 27 the beginning of a guide for a contact grill is shown (iFixit, n.d.). The brand and model of the contact grill and the part to be repaired and/or replaced are stated in the heading clearly (Figure 27, No.1). Below that, the estimated amount of time is given (Figure 27, No.2) along with the difficulty level specified by the contributor (Figure 27, No.3). It should be noted that the difficulty level is subjective and only reflects what the contributor thinks of this repair process. The skills required for the repair process are explained, along with a link to a *Soldering Skills* page (Figure 27, No.4), through which an individual can quickly learn about the basics of soldiering in general. This is an important detail for empowering individuals to undertake repair processes, as it goes beyond just sharing the repair guides and shows the ways to gain required skills as well. On the other hand, if and how an individual can learn from an online website about specific skills is debatable. Finally, the tools necessary for the repair process are listed so that the individual can prepare them beforehand (Figure 27, No.5).

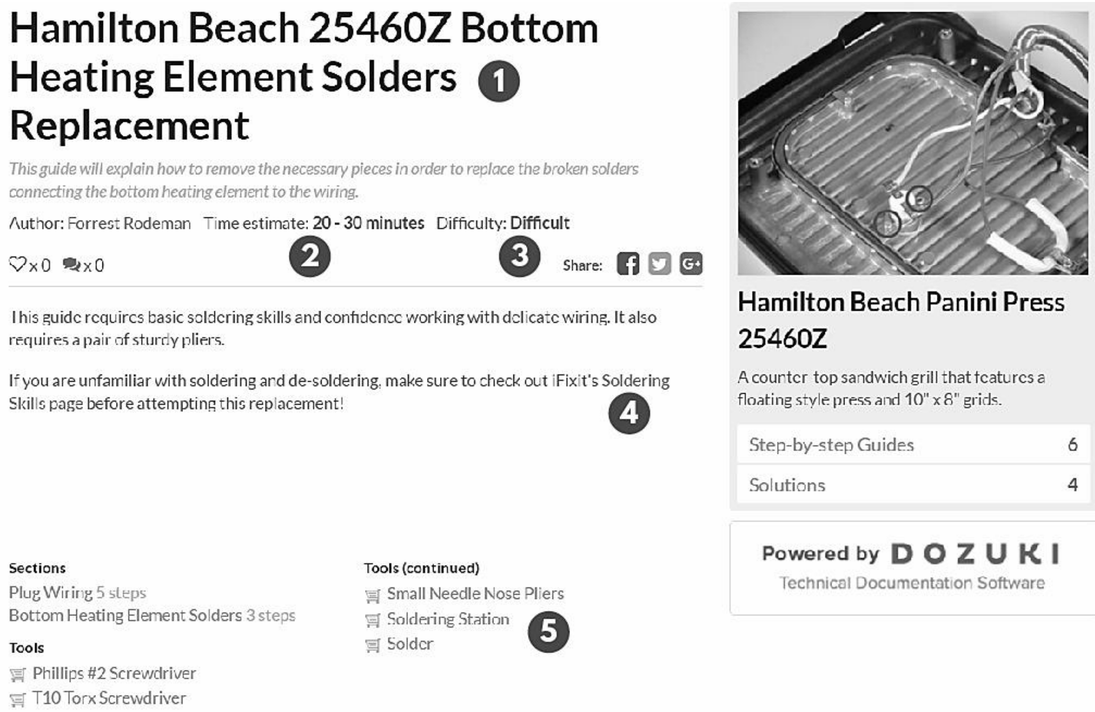

Figure 27. An iFixit repair guide page for a contact grill showing (1) the brand and model, (2) necessary amount of time, (3) difficulty level, (4) a link to learning necessary skills, and (5) necessary tools (retrieved on 25.04.2016, from https://www.ifixit.com/Guide/Hamilton+Beach+25460Z+Bottom+Heating+Element+Solders+Replacement/37951).

In Figure 28, a step of the repair guide is shown for the same contact grill. An image of the focused area for this step along with markings to point out important parts are shown explicitly (Figure 28, No.1). The purpose of this step (Figure 28, No.2) and an explanation on how to carry out the step (Figure 28, No.3) are also given. It should be noted that these guides are user-generated contents and the guides may vary according to the contributors preparing them. However, the platform provides a guideline on how to prepare a repair a guide as well (iFixit, n.d.).

iFixit is a good example of informing people on repair processes. The platform takes into account the skills of individuals and presents opportunities to empower them through step-by-step guides, indicating necessary tools and skills and skill learning pages. Informing post-use processes (i.e. maintenance, repair, reuse, upgrading) and empowering people goes hand in hand in an open process. The platform suggests ways of *informing disassembly*, *repair* and *assembly*, as well as highlights the importance of *ease of disassembly* through evaluating the reparability of products and providing people with necessary tools to easily disassemble products.

Figure 28. An iFixit repair guide step for a contact grill showing (1) image of the focused area, (2) the aim of the step, and (3) cautions and explanation of the step (retrieved on 25.04.2016, from https://www.ifixit.com/Guide/Hamilton+Beach+25460Z+Bottom+Heating+Element+Solders+Replacement/37951).

4.1.6. Open E-components

A design project developed in 2013 by Weilun Tseng in Eindhoven, the Netherlands, Open E-components project aims to rethink how electrical appliances are produced and consumed through exploring the possibilities of modularity in enabling individual production, repair and upgrading (Open E-components, n.d.). The project consists of two kinds of parts: Essentials and Additives (Figure 29). The Essentials are electrical parts for rotating (motor), lighting (lamp socket), air heating (heating coil), liquid heating (immersion heater) and warming (heating plate), which all share standardized assembly details. The way these parts will be used are defined with the other parts they are assembled with, which are the Additives. The Additives are complementary parts that can be 3D printed and assembled with the Essentials to create an appliance. Examples can be fans, feet, airways, handles, etc.

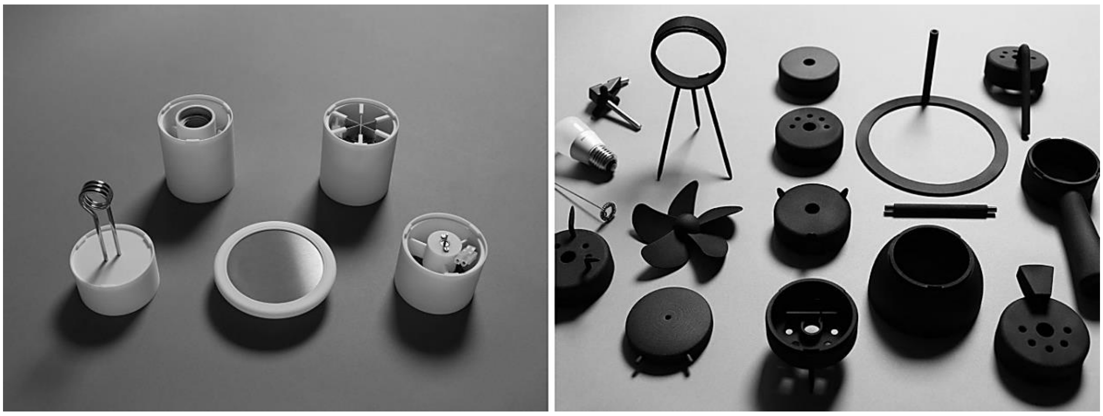

Figure 29. Open E-components: the Essentials (left) and the Additives (right) (adapted on 18.04.2016, from http://cargocollective.com/open_ecomponents).

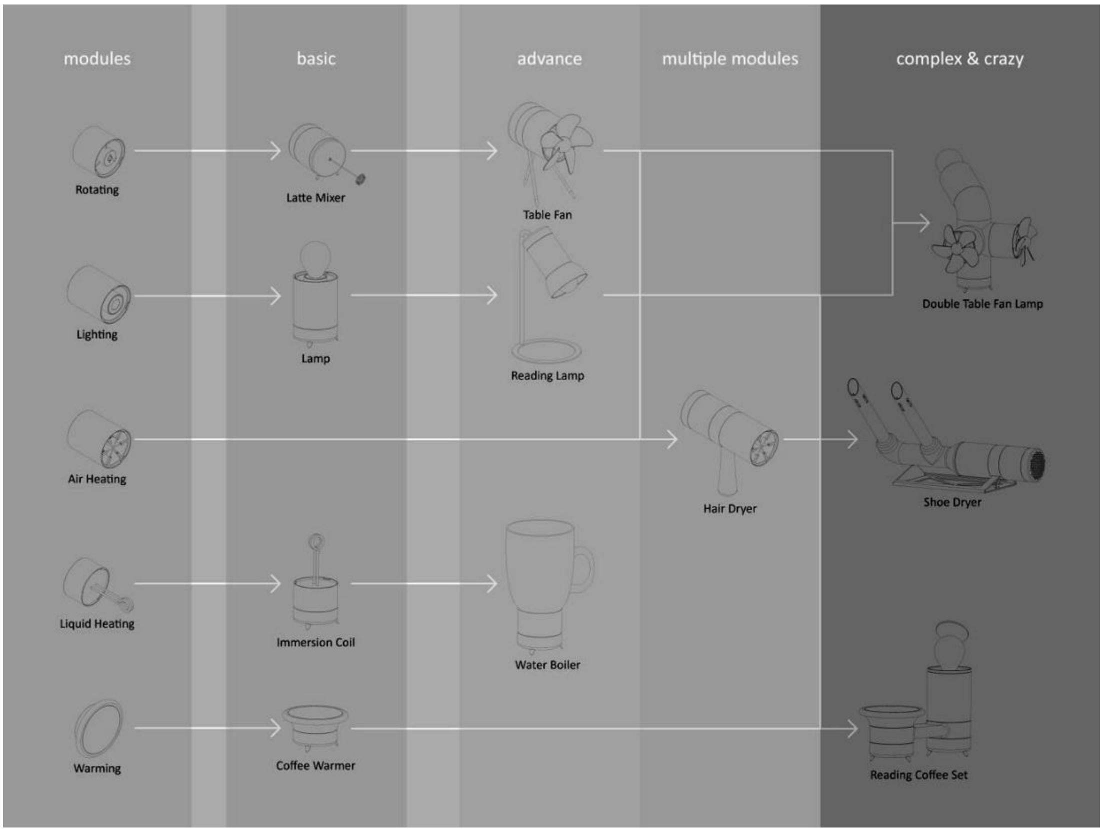

Figure 30. Flowchart showing the possibilities for the Essential modules in Open E-components project (retrieved on 18.04.2016, from http://cargocollective.com/open_ecomponents).

In Figure 30, the potentials of Essentials and Additives coming together in Open E-components platform are shown. The resultant appliances are divided into four categories: Basic (one Essential and one Additive module), Advance (one Essential and some Additives), Multiple (more than one Essentials and Additives), and Complex (Many Essentials and Additives for new kinds of appliances). This project explores the potentials of *standardizing assembly details* in creating repairable, upgradable and reusable appliances, and presents the possibility of creating many different combinations of parts to respond to *different needs and preferences* of people. However, the designer mentions the need for a major manufacturer producing the Essentials to ensure quality and durability. For the Additives, the only suggested way of producing is 3D printing. These suggest that the Essential parts are closed in nature and the contributors of the process cannot interfere with their specifications and/or design. For the Additives, even though 3D printing is becoming more wide-spread and accessible for many people, the assembly details of these parts are hard to produce with any other production technique. This limits the material selection and accessibility of parts in general, and brings forward the *local skills for production* consideration. In addition, *informing disassembly* and *informing reuse* were coded in this project, as the Essentials can be disassembled and reused in other combinations when the initial combination is no longer needed. For this purpose, an assessment is made for reusing Essentials, after they are disassembled.

4.1.7. I love OS project

"I love OS" project is developed according to Open Structure modular design grid in 2015 by Thomas Billas (n.d). The project tackles with a modular, interchangeable motor that can be placed in different assemblages of parts for different practices. The motor can be disassembled and reassembled easily and is controlled by an on-cable on/off switch (Figure 31).

In order to use the same motor in different appliances, a motor housing is used in every different appliance. In Figure 32, three different appliances (i.e. mixer, hand blender, fan) housing the same motor are shown. For the mixer and the blender, the motor is on right side of the image. For the fan, the motor is on upper part of the image. The housing enables easy assembly and disassembly of the motor. Through these explorations, the project questions the need to use the same parts (i.e. motor) in different appliances over and over. Instead of having designated motors, these appliances can simply share the same motor.

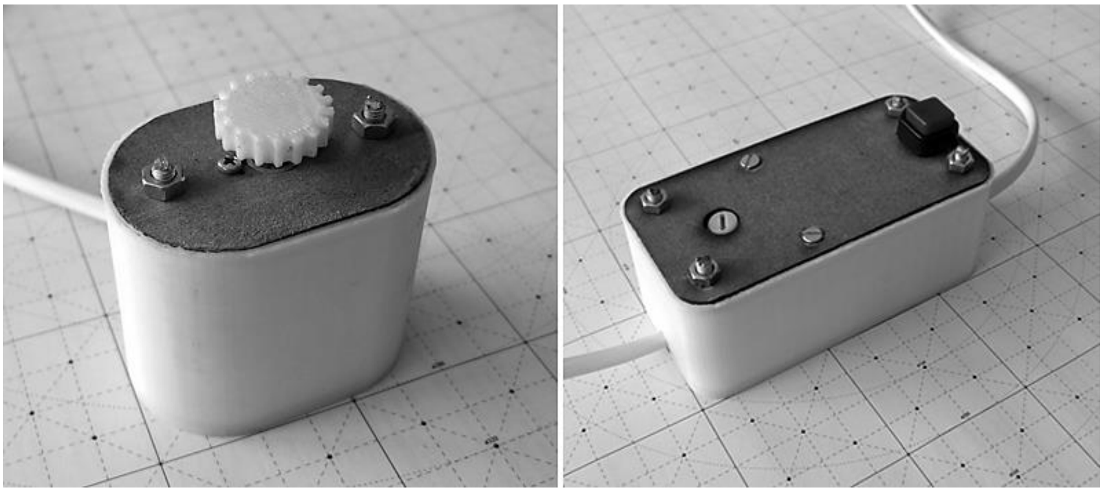

Figure 31. Motor (left) and button (right) used in I Love OS project (adapted on 18.04.2016, from http://www.coffeeandkiwi.com/work/#/i-3-os/).

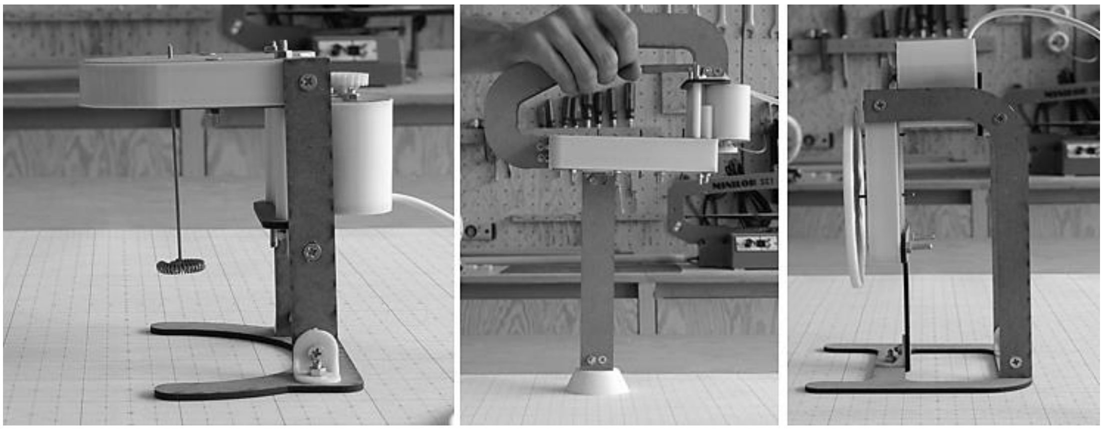

Figure 32. (Left-to-right) Mixer, blender and fan designed to use the same motor and button in I Love OS project (adapted on 18.04.2016, from http://www.coffeeandkiwi.com/work/#/i-3-os/).

Similar to most other analyzed data, this project puts emphasis on *standardizing assembly details* through the universal motor design. However, the purpose here is to *eliminate duplicate parts* that is repeatedly used in many kitchen appliances. Through designing a universal and compatible motor design which can be exchanged among appliances, the number of electrical parts are reduced and all the appliances can be upgraded by replacing one part (i.e. universal motor).

4.2. Emerging Considerations for Open, Sustainable Design Process of Kitchen Practices

In this section, the design considerations that emerged throughout the content analysis (see *Section 3.2.1. The Analysis Table*) are explained, along with the sustainability concerns and the product life-cycle phases they are related to. The sustainability concerns aid me to group these considerations, and product life-cycle phases help me position these considerations in sustainability concerns flowcharts at the end of this chapter. Table 7 (below) briefly introduces these considerations. As can be seen in the table, the considerations can respond to more than one sustainability concern, and they may affect more than one life-cycle phase. In addition, the source column shows in which analyzed data the considerations were coded, according to the list below:

1. TÜBİTAK Project No: 112M228 *by Sustain! Design Research Lab, Turkey*.
2. Re-done Appliances project *by Re-Do Studios, UK.*
3. Open Structures Water Boiler by *Jesse Howard, the Netherlands.*
4. Hacking Households, *by Leonardo Amico, Thibault Brevet, Jesse Howard, and Tilen Sepic, the Netherlands.*
5. iFixit.com Online Repair Community pages on Household Appliances.
6. Open E-components *by Weilun Tang, the Netherlands*.
7. I love OS project *by Thomas Billas, Belgium*.

Also, some of these considerations directly affect the *design* of physical parts and products (i.e. Considerations 1-12), while others are related to the *knowledge sharing* of those designs (i.e. Considerations 13-18). This is an important separation for the further stages of this study, as only *design-related considerations* were explored in the design workshops.

Table 7. Initial Open, Sustainable Design Considerations emerged through the analysis of existing concerns and explorations.

#	Consideration	Concerns	Phase	Source	Definition
1	Standardizing assembly details	Distributed Production, Ease of repair, upgrading, part reuse, Personalization	Design	1, 2, 3, 4, 6, 7	Defining the assembly details that enable part use and reuse in different assemblages of parts for different practices. Through establishing which assembly details need to be universal, design solutions can evolve through an open process, while parts can be extracted and used in different contexts.
2	Cleanable surfaces	Ease of Maintenance, Product/Part Longevity	Design	1	Designing surfaces that withstand and ease the cleaning of parts during maintenance. Such surfaces should not involve unreachable surface details that can get dirty but cannot be cleaned. On the other hand, the material selection for the parts has to be made to withstand abrasion during cleaning for part longevity.
3	Minimizing need for maintenance	Ease of Maintenance, Product/Part Longevity	Design	1	Design solutions that prevent spillages, overflows, etc. need to be developed. Such solutions are important to eliminate extra maintenance for parts and kitchen environment, which do not normally come into contact with food & ingredients.
4	Feedback on maintenance need	Ease of Maintenance, Product/Part Longevity	Design	1	The need for maintenance should be conveyed to anyone using the open design solution. Through different indicators – can be high-tech like LEDs and sound, or low-tech like transparent parts – feedback on when parts need maintenance can be conveyed to people.
5	Feedback on breakdown reasons	Ease of repair, part reuse	Design	1	Design details to indicate if and when parts fail should be developed for easing the repair and reuse of parts/assemblages of parts. The indicators can be high-tech like LEDs and sound, or low-tech like changing colors, visible details, etc.
6	Ease of disassembly	Ease of repair, part reuse	Design	1, 5	The assemblage of parts should be easily disassembled during the post use processes. Hence, the part designs should be considered along with their intended assemblages, and parts should be easily removed when necessary.
7	Responding to needs & preferences	Personalization	Design	1, 6	Different parts that respond to the changing needs and preferences of different people should be able to be brought together, resulting in different and flexible assemblages of parts. Both different needs and preferences of different people can be addressed, as well as changing needs and preferences of the same individual.

Table 7. Initial Open, Sustainable Design Considerations emerged through the analysis of existing concerns and explorations (continued).

8	Using readily-available parts	Distributed Production, Part Reuse	Design & Produce	2, 4	Decision to use and/or reuse local retail parts that can be acquired through local retail channels should be made during open, sustainable design process. These parts can be made of materials that individual cannot produce himself/herself. On the other hand, they are standard parts that can be replaced and reused easily during post-use processes.
9	Eliminating duplicate parts	Part Reuse	Design & Use	7	Similar parts that exist in different assemblages of parts need to be addressed and their number should be reduced. These are parts like motors, heating elements, containers, etc. that are duplicated in different appliances.
10	Disassembly for maintenance	Ease of maintenance, Product/Part Longevity	Design & Post-use	1	Some parts may need to be disassembled for cleaning/maintenance. For some parts, they need to be disassembled so that surfaces that come into contact with ingredients can be reached. For others, they are positioned close to the electrical parts and they should be separated to prevent water damage.
11	Individual skills for production	Distributed Production, Personalization, Part Reuse	Produce	3	Point-of-use production is an important aspect of open design. Individuals are directly involved with the production of parts and understands how they function, which empowers them through post-use processes. It also eliminates the transportation footprint to some extent.
12	Local skills for production	Distributed Production, Ease of repair, part reuse	Produce	2, 3, 6	Local skills refer to craftsmen, batch producers, service providers, etc. that are producing parts/products. Parts that cannot be produced individually, can be produced locally. Understanding their capabilities and utilizing them empower the local economy.
13	Informing assembly	Distributed Production, Personalization, Ease of repair, upgrading, part reuse	Produce	1, 2, 3, 5	Assembling parts may require different skills and/or tools that the contributors may not be aware of right away. Informing them about the ways of assembling, the tools they require to carry out the task and the steps they need to take for proper assembling is needed.

Table 7. Initial Open, Sustainable Design Considerations emerged through the analysis of existing concerns and explorations (continued).

14	Informing use	Ease of maintenance, Product/Part Longevity	Use	1	The way parts and assemblages of parts used change greatly for each individual and for each practice. These ways of usage should be shared along with opportunities and limitations to prevent misuses that result in part failure and ensure part longevity.
15	Informing disassembly	Ease of repair, Part reuse	Post-use	1, 2, 5, 6	Disassembly is an important part of post-use processes, as the parts have to be disassembled first to be replaced, repaired and reused. The ways of disassembling parts according to the way they were assembled in the first place should be conveyed clearly to other individuals. Hence, ways of informing people on disassembly should be designed.
16	Informing maintenance	Product/Part Longevity	Post-use	1	Different materials, surface details and parts require different ways of maintenance. The harm to the parts due to improper maintenance may not be visible right away, which brings forth the need of informing individuals on ways of proper maintenance and their reasoning.
17	Informing repair	Ease of repair	Post-use	1, 5	For the repair of parts and assemblage of parts, the reasons for breakdown and the ways to repair them should be informed to individuals to enable them carry out repairing themselves, or to local craftsmen and repairmen to provide the repair service properly.
18	Informing reuse	Part reuse	Post-use	1, 2, 6	The decision to reuse parts has to be made according to the condition and compatibility of the salvaged parts to the next assemblage of parts it will utilized in. Such decisions may require certain kinds of knowledge and/or expertise, which should be informed to individuals in an open process.

Some of these considerations are directly taken from the analyzed data as defined in the projects themselves, as they were in line with purposes of the study (e.g. *Cleanable Surfaces* from the TÜBİTAK project). Others were analyzed in the data and reframed to be meaningful throughout this study (e.g. *Eliminating Duplicate Parts* from the I Love OS Project). In the following sections, these open, sustainable design considerations are explained more in detail, including (1) explanation of new terms,

(2) explanation of the consideration, (3) the affected kinds of parts, (4) flowcharts of considerations according to creating, sharing, implementing and adapting, and (5) limitations of considerations.

4.2.1. Initial Design Considerations for Kitchen Practices

In this section, the initial 12 considerations in Table 7 which directly affect the design of physical parts and products are explained. These considerations should be kept in mind while designing the open parts to achieve product/part longevity, and they are later used in the design workshops to facilitate idea-generation.

4.2.1.1. Standardizing Assembly Details

Assembly details are the definitive design details that regulates the compatibility of different parts and during an open, sustainable design process incompatibility of open parts and other parts (i.e. local retail and international supply parts) may inhibit the development of open, sustainable design solutions. On the other hand, some international supply parts (e.g. motors, heating elements) already have standardized assembly details suitable for mass-production and assembly, which can be taken advantage of in an open design process. Furthermore, incompatibility among open part designs also poses a problem for replacement and reuse of those parts in the post-use process (i.e. repair, reuse, upgrading). Drawing upon these, exploring the opportunities created by standardized assembly details need to be explored as it enables the use and reuse of parts for different purposes in the different assemblages of parts. These opportunities are explored in the analyzed explorations through the division of parts into two different groups for kitchen appliances: essentials (i.e. standardized parts with electrical components) and additives (i.e. any other part without electrical components) in Open E-components project. However, there are many other parts (i.e. other than electrical parts) that can be used for different purposes if their assembly details are standardized (e.g. containers, strainers, lids, etc.), which can also transform the kitchen practices through different assemblages.

As a design consideration, standardizing assembly details can lead to easier sharing of part designs through eliminating the incompatibility issue among parts. The important assembly details for assemblages in the context of kitchen practices can be defined through exploration, and open parts abiding by these standardized assembly details can be designed for easier sharing and replication. Furthermore, if the assembly details allow easy disassembly and reassembly, one part can be used for different purposes in the kitchen (e.g. using the same container for boiling water, making coffee, etc.). Participation scenarios for this consideration is depicted in Figure 33 and they are explained briefly as follows.

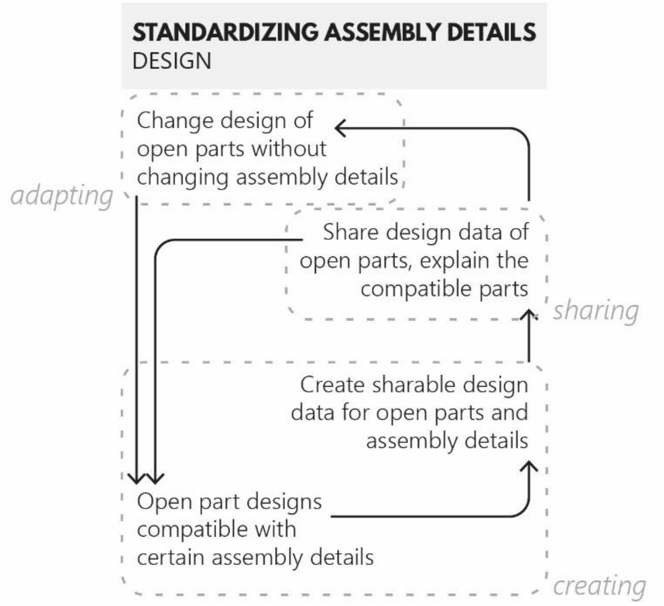

Figure 33. Flowchart for Standardizing Assembly Details.

Creating and sharing new design-related knowledge: Open part designs should be created with thorough explanations on their assembly details. Any used assembly detail should be explained through the materials and tools necessary for assembling those open parts, the compatible parts for these assembly details that can be brought together, the important design details that should be kept if another contributor wants to alter its design. Consequently, sharing such a knowledge would enable contributors to understand the parts compatibility, implement the assembly details in different open, sustainable design solutions and ensure that those parts can be reused or repurposed. This consideration is important to find a common ground between different contributors and ease the sharing of design-related knowledge through shared and abided by design limitations.

Adapting shared design-related knowledge: The shared part designs can be adapted according to functional or aesthetical needs and preferences as long as assembly details are kept unchanged. Material selection for open parts, can change and parts with different forms and sizes can be designed. These part designs can then be shared, expanding the solution ground offered through same assembly details, creating new opportunities for new assemblages of parts for different kitchen practices.

Implementing shared design-related knowledge: The shared design knowledge can be implemented as it is and the opportunities enabled by shared assembly details can be explored to create different assemblages of parts. Producing/using parts with shared assembly details enables the reuse of parts later or the assemblages can be upgraded with new, emerging part designs that use the same assembly details.

4.2.1.2. Cleanable Surfaces

For kitchen appliances, surfaces that come into contact with ingredients are cleaned after every use, or at least in use intervals (e.g. after it was used for three times). In the small kitchen appliances that exist, these surfaces are heating plates, inside of the containers, blades and other accessories for processing food. However, these surfaces may prove to be hard to clean due to several reasons, like unreachable surface details (e.g. dents, narrow container openings, etc.) and material selection (e.g. plastic containers get scratched and retain the stains). These problems are important for part longevity, as these parts become unusable over time due to either accumulated stains or wear and tear from maintenance.

During the design phase of an open, sustainable process for small kitchen appliances, these problems have to be kept in mind, and cleanable surfaces that withstand and ease the cleaning of parts during maintenance should be developed. When designing parts, if and how they come into contact with ingredients should be considered, and all surfaces should be reachable for ease of cleaning and maintenance and produced out of materials that withstand wear, which in return elongates the lifespan of parts. What this consideration includes is depicted in Figure 34 and participation scenarios are explained below.

Creating and sharing new design-related knowledge: As mentioned above, easy to clean surfaces without unreachable surfaces should be designed to be made of materials that can withstand wear and tear due to maintenance. The design data of these parts should include the reasons for decisions on surface details and how they affect the maintenance process later on. The material selection and the properties of the material with regards to the maintenance endurance should be explained in detail. This knowledge enables other contributors to adapt the part designs accordingly, without eliminating properties that make the surfaces cleanable.

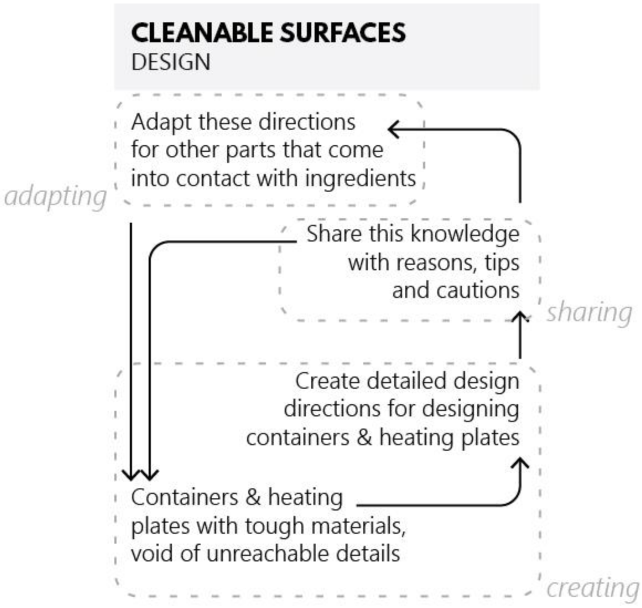

Figure 34. Flowchart for Cleanable Surfaces.

Adapting shared design-related knowledge: The shared design data can be utilized for other parts that come into contact with ingredients (e.g. surface detail of coffee machine pot used in tea maker). The knowledge on surface details and materials selection can also be expanded with different explorations of material opportunities or needs and preferences in different practices. The part designs can be changed to conform to other practices in which different surface of the parts need maintenance as well. Similarly, all this knowledge should be shared to expand the existing knowledge.

Implementing shared design-related knowledge: The design data of the parts can be implemented directly by other contributors; however, the surface detail decisions should be conveyed to ensure replicating the properties that make these surfaces cleanable.

4.2.1.3. Minimizing Need for Maintenance

The need for maintenance refers to the parts that need to be cleaned and maintained after use. However, the ingredients used in small kitchen appliances can spill over to parts and/or the kitchen environment, which would not come into contact with food and other ingredients. Some examples of this can be overflowing Turkish coffee, splashing soup from the hand blender, or dripping tea from the bottom of the teapot. While these situations seem harmless, they create additional steps for the maintenance of the parts and assemblages of parts.

Minimizing the need for maintenance is a consideration that takes into account these situations. The design of certain parts (e.g. beakers of the teapots, apparatus of blenders, container of the Turkish coffee maker, etc.) should be developed taking these situations into account to eliminate the additional need for maintenance. Eliminating this additional need for maintenance and cleaning of parts is important to elongate the lifespan of parts and the assemblages of parts. However, the design details that are important for this consideration should be clearly identified and resolved. Figure 35 (below) shows how this consideration works in the form of a flowchart, followed by the explanations for each scenario.

Creating and sharing new design-related knowledge: For this consideration, creating design data of parts that prevent spillages, splashes, etc. and how these design solutions work are important knowledge to be created and shared. This knowledge should include detailed accounts of design directions as well as explanatory guides for other contributors to adapt and/or implement solutions.

Adapting shared design-related knowledge: The shared part designs that minimize the need for maintenance can be changed according to needs and preferences, or to develop the solutions further. If the contributor aims to change the design for personalization of parts, s/he should try to preserve the details that minimize the need for maintenance. If the aim is to develop the design solutions further for this consideration, the changes made and the reasons why should be explained in detail.

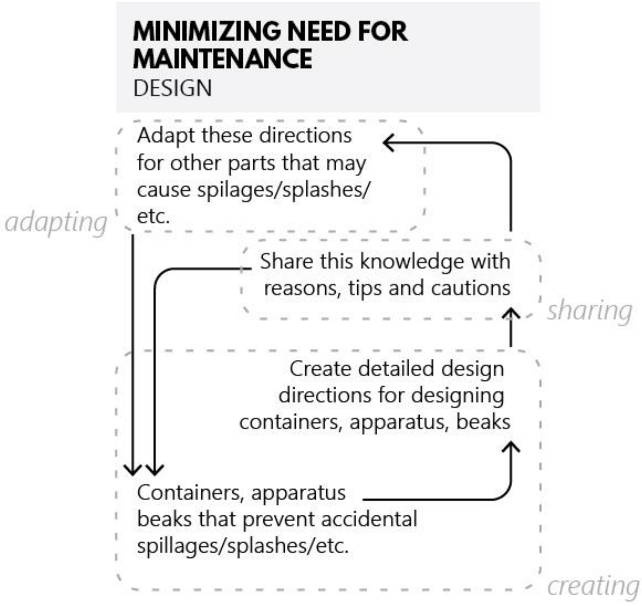

Figure 35. Flowchart for Minimizing Need for Maintenance.

Implementing shared design-related knowledge: Following the shared knowledge on minimizing maintenance and explanatory guides for designing the parts, the design solution can be reproduced by other contributors as well.

4.2.1.4. Feedback on Maintenance Need

When the parts need maintenance, this may be concealed to people who are using a small kitchen appliance. It is hard to see the calcification inside the kettles with opaque containers, or burnt ingredients on a black heating plate. Hence, the intervals of maintenance should be reminded to the individuals who are using the design solution to ensure that they don’t become unusable due to neglecting its maintenance.

In an open, sustainable design process, this can be done through design details that show and/or make visible the situation of the parts, if they need maintenance. These design details can be shared with other contributors and replicated in different iterations of the design solution, giving feedback on the need for maintenance. Such solutions can be simple design details and/or materials choices, like using transparent materials for containers or using different colored heating plates to bring forth the burnt ingredients. They can also be indicators, like blinking LEDs or beeping sounds after a certain time of using the parts. In Figure 36, how this consideration works is in an open, sustainable design process is depicted.

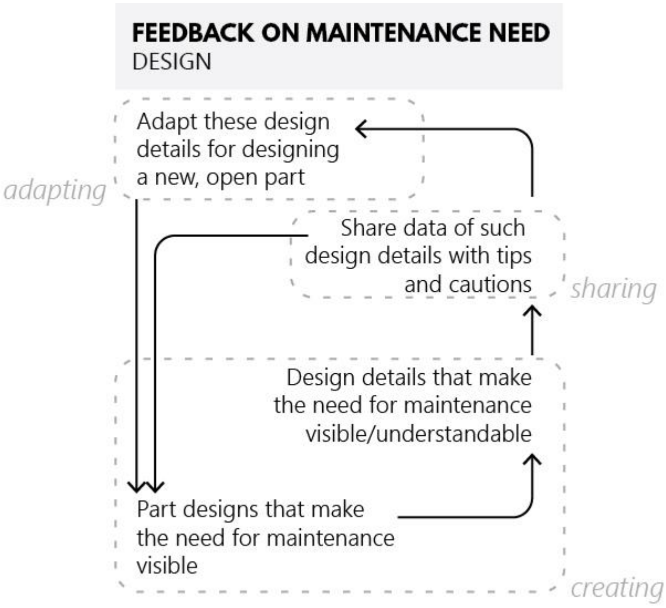

Figure 36. Flowchart for Feedback on Maintenance Need.

Creating and sharing new design-related knowledge: For this consideration, the design solutions that provide feedback on maintenance needs should be created, along with the way they work and the way they provide feedback. Other contributors should be able to understand how the feedback works in order to adapt and/or replicate the feedback in another iteration of the open design solution. The way these solutions provide feedback is also important for other individuals who have adopted the solution, to be able to comprehend the feedback in a proper manner.

Adapting shared design-related knowledge: The shared knowledge on maintenance feedback solutions can be used in different contexts and for different practices through adapting the solution to the part at hand. Such adaptations on maintenance feedback solutions should be shared along with the changed details and their effects on the feedbacks and the open solution itself.

Implementing shared design-related knowledge: Implementing shared maintenance feedback solutions is important to prevent part breakdown due to neglecting maintenance. With the help of feedbacks, individuals using the parts are reminded to tend to the parts, which in turn elongates the lifecycle of parts.

4.2.1.5. Feedback on Breakdown Reasons

When parts and/or products breakdown, the reason for the failure and the affected part are hard to pin down. This is due to the 'black box' nature of the existing small kitchen appliances as well as the lack of knowledge on parts and how they function. Consequently, designing feedback mechanisms on the nature of the problem that caused the failure of part/assemblage of parts is suggested through this consideration.

Such feedbacks can ease the repair process through locating the failed part and/or enable the reuse of the functioning parts. There are existing design solutions for such feedbacks, like an additional bulb or LED to show if the electronic components are receiving power, or color-changing strips to indicate water damage. Such inconspicuous details are useful during the open, sustainable design process, if the contributors know how to comprehend them. This consideration emerged especially for electrical parts, as it is hard to understand the reasons for part failure. In Figure 37, how this consideration works is depicted.

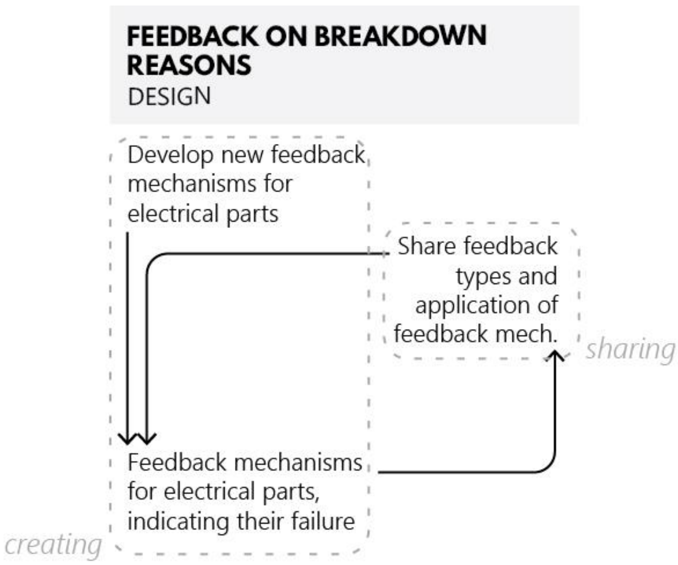

Figure 37. Flowchart for Feedback on Breakdown Reasons.

As can be seen in Figure 37, this consideration lacks the “adapting” step, as the analyzed content did not indicate any kind of opportunity for such adaptation. Feedbacks on breakdown reasons are generally inconspicuous, and they are very standard compared to other kinds of feedback. Hence, this consideration is about either creating a new feedback mechanism, or implementing an existing one.

Creating and sharing new design-related knowledge: Contributors should design feedback mechanisms that indicate the breakdown reasons of electrical parts. Such solutions should be shared including the way to build these mechanisms, what the indications mean and how to respond to them.

Implementing shared design-related knowledge: Through the shared design knowledge, other contributors can use the shared feedback mechanisms for their own open, sustainable design solutions and get notified of the breakdown reasons during post-use processes, empowering contributors in repair.

4.2.1.6. Ease of Disassembly

Ease of disassembly is an important consideration as the all the parts of an open design solution need to be disassembled during the post-use processes. The assembly details of the parts should enable easy disassembly, which should be considered when designing parts and the assemblages of parts. Additionally, not every post-use process requires disassembling all the parts. For example, replacing just one open part to upgrade the assemblage of parts is also within the realm of possibilities, which would only require removing that specific part, if it is possible. Considering these possibilities and developing part and assembly detail designs to conform these possibilities eases the disassembly, and consequently all of the post-use processes. This consideration is about all parts that take part in an open, sustainable design process. Hence, how to disassemble every one of them should be considered throughout the design phase. In Figure 38, ease of disassembly is depicted as a flowchart.

Creating and sharing new design-related knowledge: Open part designs should be easy to disassemble for post-use processes (i.e. repair, reuse and upgrading). Ways of disassembling the parts need to be kept in mind when designing a part, eliminating any permanent, irreversible attachment of two parts. The design knowledge for sharing these open solutions should include the design details of the assembly and disassembly for open parts, and the ways the assembly need to be carried out to ease the disassembly process later on. Additionally, any design solutions for disassembling only one part for post-use processes need to be explained in detail, and how this affects the design of that part and its adjacent parts.

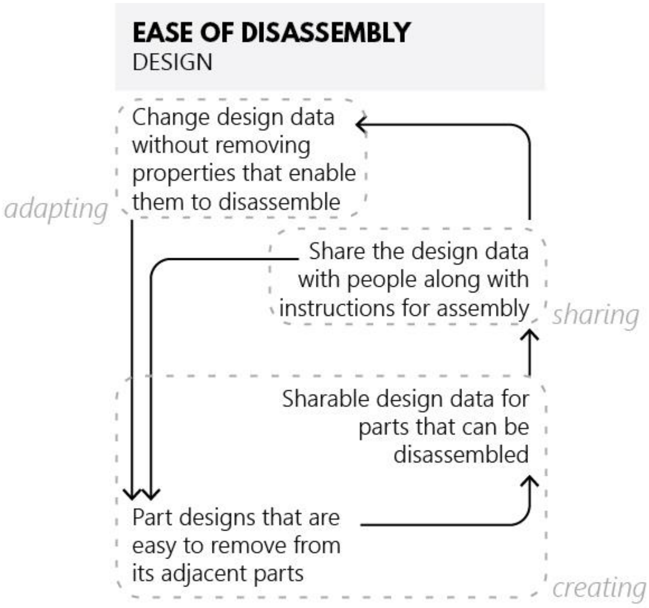

Figure 38. Flowchart for Ease of Disassembly.

Adapting shared design-related knowledge: The design solutions with design details that eases disassembly can be adapted when designing other open parts. On the other hand, any shared open part design can be changed, and still retain its properties that ease the disassembly. Contributors should share how the open part designs are changed and the way they kept these properties.

Implementing shared design-related knowledge: Contributors can implement the shared open part designs and ensure that they will be easy disassemble during post-use processes. Through using these open part designs, assemblages of parts that enable easier post-use services can become wide-spread.

4.2.1.7. Responding to Needs & Preferences

Closely linked to personalization concern of this Ph.D. study, responding to needs & preferences consideration is about different open part designs and assemblages of parts that respond to the different and changing needs and preferences of different people. These open parts should be able to be brought together, resulting in different and flexible assemblages of parts. Open parts should be able to be replaced to upgrade the assemblage of parts when the needs of the same individual changes as well. The needs and preferences can be functional needs of the practice (e.g. the capacity of the parts with regards to size, volume, etc.,) or aesthetic preferences (e.g. form and color of parts).

In the context of an open, sustainable design process, this consideration is important for the dissemination and adoption of open solutions by different individuals as it brings forth the importance of flexibility in bringing parts together for a practice. Individuals can design parts and assemblages of parts responding to their own, unique needs and preferences. However, the issue of compatibility among open parts may inhibit the practical implications of this consideration, which is explained in *Standardizing Assembly Details* consideration. Figure 39 shows the way this consideration works as a flowchart and its scenarios are explained below.

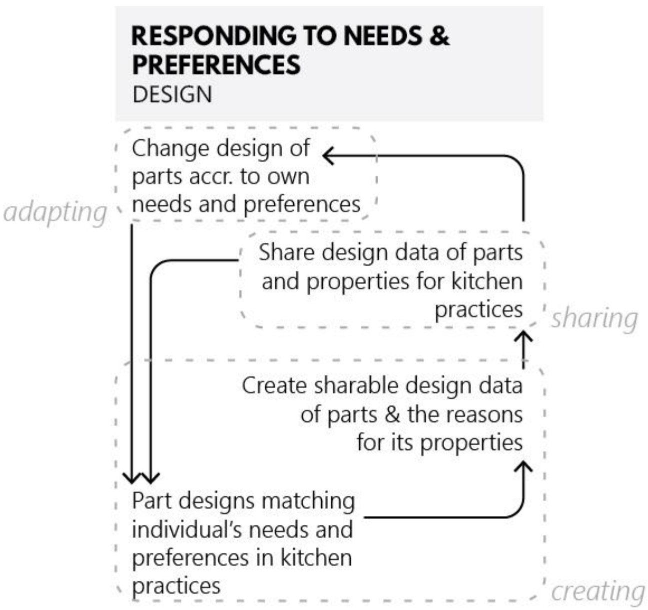

Figure 39. Flowchart for Responding to Needs & Preferences.

Creating and sharing new design-related knowledge: During an open, sustainable design process, the resultant open solutions can respond to needs and preferences of individual contributors. However, pointing out how other possible assemblages of parts that respond to other contributors' needs and preferences for kitchen practices through the open solutions should be shared as well. This includes the needs and preferences of the individual, how the open solution responds to them and the open part designs that can be adapted to meet others' needs and preferences through using different parts or altering their designs. Sharing such knowledge enables personalization of open solutions, and can also show the ways of upgrading the open solution as the needs and preferences change.

Adapting shared design-related knowledge: Contributors of the open, sustainable design process can change the design of open parts and adapt them to their own needs and preferences. This is enabled by the shared design knowledge as mentioned above. Adapted assemblages of parts should also be shared along with how the part designs were changed and how they respond to new needs and preferences. Consequently, different versions of the assemblages responding to diverse needs can be available for others to implement.

Implementing shared design-related knowledge: Individuals can look for and find shared open design solutions that fit their own needs and preferences. Using these design solutions would enrich their kitchen practices, and on the other hand help disseminate the acceptance of open, sustainable design solutions.

4.2.1.8. Using Readily-Available Parts:

Readily-available parts refer to the parts that are already in production and the person who is taking part in the open design process either already have those parts in possession or they can easily acquire them through local retail stores. These parts are generally standardized through the requirements of other markets, which creates other advantages for open design solutions. They can be repurposed when disassembled, or they can be replaced if they are broken. Examples in the analyzed design explorations include chemistry beakers – which are made of glass and can withstand heat – and wine bottles – which are again made of glass and fashion standard-sized orifices. These parts are made of materials (e.g. glass) that would otherwise require either exceptional skills to produce or access to precise manufacturing techniques, and they offer unique characteristics (e.g. transparency, no-leakage structure, etc.) which may be important for the open design solution at hand.

As a design consideration, repurposing such parts for different purposes expands the solution ground for the design problem. For example, an open design solution to boil water can utilize a glass chemistry beaker, which saves the contributor from devising measures to seal a container. Also, if the beaker breaks at some point, it can be easily replaced since the part is available in local retail shops. In the context of an open, sustainable design process, the readily-available parts that are utilized are prepared for assembly and other open parts need to be designed to house these readily available parts. In such a process, the alternative scenarios are explained briefly as follows and visualized in Figure 40.

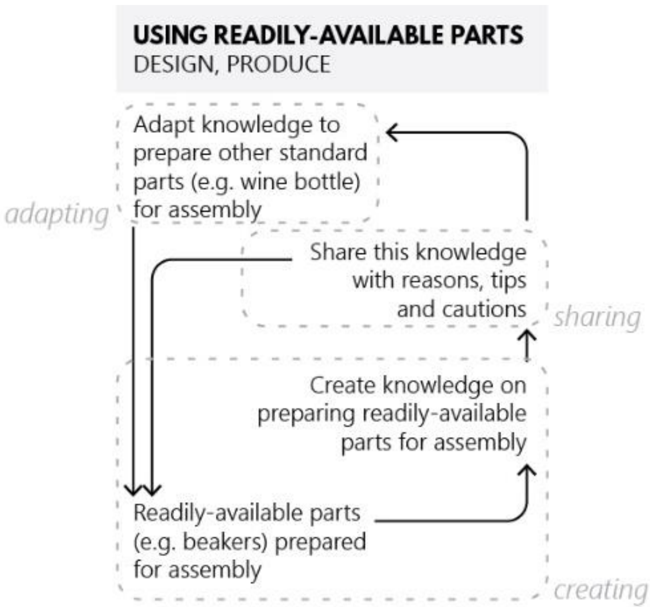

Figure 40. Flowchart for Using Readily-Available Parts.

Creating and sharing new design-related knowledge: When a contributor decides to use a readily available part for an open design solution, s/he needs to prepare that part to assemble it with other open parts. Such a preparation may require changing the form of the part altogether, or simply adding assembly details like holes, adhesives, etc. The details of this preparation should be well documented and the reasons for the preparation need to be explained in detail, so that created information can be conveyed to other people properly. The created knowledge needs to include the reasons for using such a part, how to handle and alter the material it is made of, required skills and equipment for the alteration of the part, and to which open parts it will become compatible with after such an alteration. This knowledge can be shared with other people through different means – online in the form of videos, guidelines, etc. and physically in workshops and open events.

Adapting shared design-related knowledge: If the shared knowledge includes the above mentioned, it is possible for another contributor to adapt that knowledge for different purposes. Possibilities include using different readily available parts for the same purpose, altering different parts made out of the same material for the same or different purposes, and designing new open parts compatible with the shared readily-available parts. Such possibilities are created by open sharing of knowledge, which will be seen in the following design considerations as well. If the process of adapting is well-documented and shared openly with other people as well, alternatives to the initial design decision to use a specific part can be conveyed to people.

Implementing shared design-related knowledge: It is also possible for a contributor to simply replicate the shared knowledge on using readily-available materials. In this case, through following the shared knowledge properly, open, sustainable design solutions are disseminated and readily-available parts that are easy to replace in the post-use processes are being used for kitchen practices.

4.2.1.9. Eliminating Duplicate Parts

Duplicate parts refer to the existence of the same or similar parts existing inside different kitchen appliances. There is a motor in hand blenders, choppers, stand-alone blenders, food processors, mixers, etc. Similarly, there is a heating element in contact grills, kettles, coffee makers, and so on. The kind of parts can be extended to cables, on/off switches, lids, etc. Even though these products are hardly used at the same time, they have the same/similar parts inside them, unused most of the time.

Eliminating duplicate parts consideration focuses on these parts and promotes the exploration of modular solutions for these parts, which are interchangeable in the kitchen environment. This consideration is closely related to *standardizing assembly details*, with a difference in the kind of assembly it requires. Parts need to be easily removed from an assemblage of parts to another within the kitchen environment between kitchen practices. Through using the same part for different practices, the number of parts can be reduced in the households and the lifespan of the part will be used to the fullest. However, it also brings forth other issues of overcoming compatibility of different parts and designing universal assembly details that can fit into every practice properly. Such parts may be hard to be adapted by other contributors of the open, sustainable design process in design as well. On the other hand, any contributor can explore the use of such a universal part in different practices. Figure 41 shows the flowchart of this consideration.

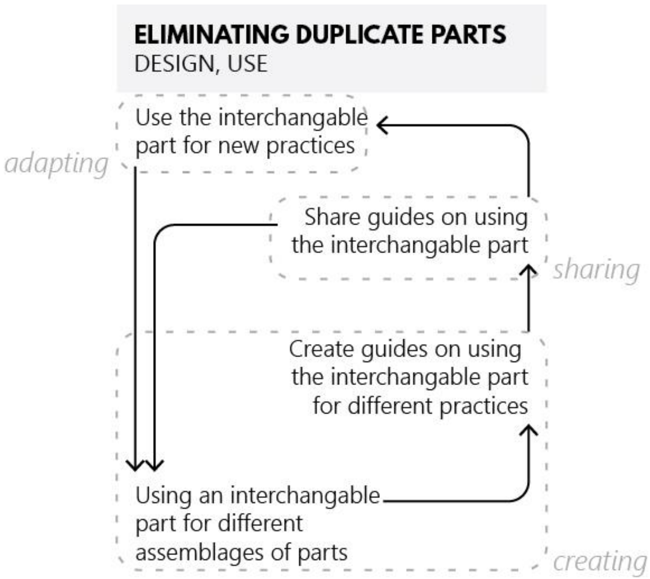

Figure 41. Flowchart for Eliminating Duplicate Parts.

Creating and sharing new design-related knowledge: Contributors can design universal, interchangeable parts that can be swapped among different assemblages of parts between different kitchen practices. These parts need to be easily disassembled and re-assembled in the kitchen environment, and may require compatible housing in the assemblages of parts. The design data and knowledge about the universal part should be shared with other contributors, along with its function and the way it works, its requirements to be used in different assemblages and the ways of swapping them in and out between practices.

Adapting shared design-related knowledge: The design of the universal part needs to be retained, yet other contributors can explore other possibilities enabled by the same universal, interchangeable part for different kitchen practices, and design new assemblages of parts. These explorations need to be shared as well, along with how the universal part is being used in the new assemblage, and how it fits with the explored practice.

Implementing shared design-related knowledge: Contributors may utilize the design knowledge without changing it and use the universal part for kitchen practices in the way shared by other contributors. Open universal part solutions eliminate the need for acquiring and/or producing a new part for each assemblage of parts for different practices.

4.2.1.10. Disassembly for Maintenance

Although it may sound similar to the *ease of disassembly* consideration mentioned before, disassembly for maintenance is a middle step for maintenance processes. It is not about disassembling of parts completely, but removing some parts so that they do not get damaged during maintenance and/or other parts can be maintained easily. The parts needed to be considered accordingly are wide-ranging. Electrical parts (e.g. motor, heating elements, switches, cables, etc.) may need to be disassembled in order to prevent water damage to them. On the other hand, the lids of containers may need to be removed, so that containers can be cleaned properly.

Such a disassembly needs to be done in maintenance intervals (i.e. after every use, or a number of uses), which requires different assembly details that ease the disassembly yet retains safe attachment at the same time. Designing these details may require design expertise for durable and safe outcomes, which every contributor might not have. Incompetent details may get damaged and break down over time, shortening the lifespan of the part greatly. Hence, contributors should be warned about these possibilities accordingly. Figure 42 shows the flowchart for this consideration.

Creating and sharing new design-related knowledge: As mentioned before, in order to carry out maintenance properly and prevent damage to electrical parts, some of the parts may need to be disassembled before maintenance. Hence, open parts should be designed accordingly with assembly details to conform to such need. The contributor should also create guides on how to carry out this partial assembly and share it with other contributors of the open, sustainable design process. The shared information should include the reason for the partial assembly, and how it affects the maintenance process, the ways of assembling them back after the maintenance process properly and the design details of the assembly details enabling this.

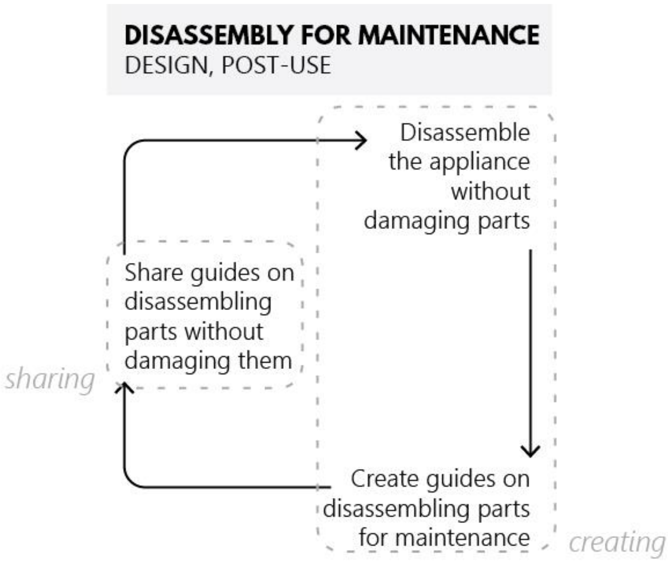

Figure 42. Flowchart for Disassembly for Maintenance.

Implementing shared design-related knowledge: The shared design information on assembly details should be implemented by other contributors, making sure that those details enable re-assembly. This consideration skips the *adapting* scenario, as the design details enabling the partial disassembly should be retained in every other iteration of the open design solution.

4.2.1.11. Individual Skills for Production

In Literature Review chapter, the expanding and hybrid roles of people were mentioned. Users are not regarded as passive users of produced goods, but they are regarded as capable as designers and producers as well. It is not an assumption on already possessing necessary skills or tools, but a potential on gathering those skills and tools (see *Section 2.2.1.1. Contributors/People*). The OS Water Boiler revealed this as well, highlighting the importance of point-of-use production. This also enables the interference of individuals for personalizing the open solution. Furthermore, this involvement also empowers them to carry out post-use process themselves, as they become familiar with how parts should be brought together. In addition, individual production reduces the transportation footprint according to the level of the production processes. Individuals may produce everything themselves or assemble some individually produced parts and mass or locally produced parts. In the case for kitchen appliances, some mass-produced parts (e.g. motor, gears, etc.) are brought together with individually and locally produced parts to ensure part longevity of complex components. Figure 43 shows the flowchart for this consideration.

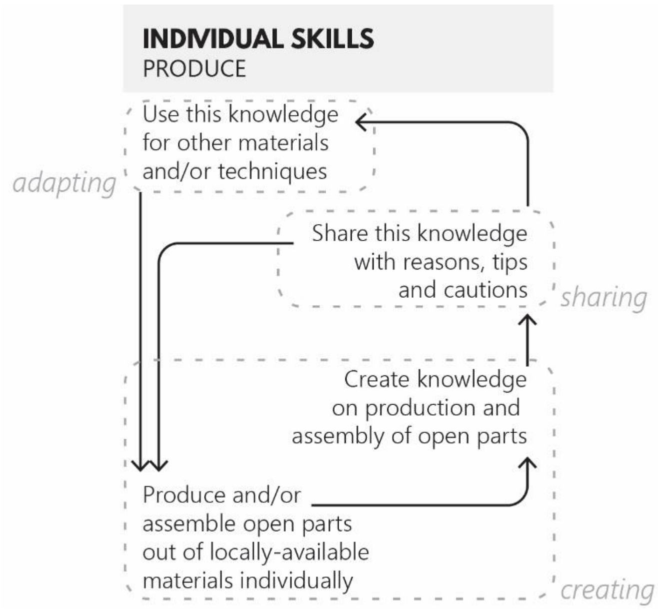

Figure 43. Flowchart for Individual Skills for Production.

Creating and sharing new design-related knowledge: Upon producing parts from locally-available materials through reachable tools or individually possible techniques, knowledge on how to carry out these processes should be created. This can be in different forms, like videos, visual guides, textual explanations, etc. Throughout these production processes, making notes on experienced and/or potential problems is also important. As a result, the knowledge on individual production and assembly can be generated not only as a step-by-step guide, but also as a list of cautions and tips that are relevant to these processes (e.g. how to handle materials, delicate parts, etc.). In the end, this knowledge is shared for other people to apply and explore further.

Adapting shared design-related knowledge: The generated knowledge will probably be focusing on one production technique or material; however, this does not limit varying ways of producing a part. Alternative ways of individually producing and assembling parts (e.g. digital fabrication tools or acquiring skills) can be explored depending on the availability of materials (e.g. local materials), reachability of production tools (e.g. workshops) and the quality of the desired outcome (e.g. surface finishes). Through the shared knowledge, an individual can understand the way the parts can be produced and assembled for a certain outcome, and use different materials, apply different production techniques, or simply improve the shared way of production for better quality outcomes. These alternative ways of producing parts is shared as new guides or as new cautions and tips on the existing guides.

Implementing shared design-related knowledge: The shared ways of producing and assembling parts should be implemented by others to ensure the required part properties and part longevity. Through this implementation, individuals can reproduce any part properly and use those parts for the shared open solution.

4.2.1.12. Local Skills for Production

Localization is an important aspect for sustainability with regards to product/part longevity, enabling post-use processes and empowering the local producers [see *Section 2.1.2. Centralized (Mass-) Production vs. Localization*]. The analysis of existing concerns and explorations on kitchen appliances revealed that local skills can be depended upon to produce parts that are not necessarily required to be mass-produced, but are too complex or too skill-dependent to be produced individually. Understanding the production capabilities of local producers (i.e. craftsmen, batch-scale producers) enables the integration of their expertise on production and their experience with local needs and preferences on design. However, knowledge on skill-dependent production tasks that require specialized equipment (e.g. woodworking, pottery, glass-blowing, etc.) cannot be easily transferred to other people. Thus, the parts that need certain skills and expertise are outsourced (outsourcing as a part of open design was mentioned in *Section 2.2.1.3. Outcomes/Parts and Objects*) from local producers, eliminating transportation carbon footprint, enabling local post-use services and empowering local economy. Figure 44 shows the flowchart for this consideration.

Due to the hardness of sharing knowledge on skill-dependent tasks, this consideration only focuses on producing structural parts out of locally-available materials and providing these parts to individuals to bring them together with other individually produced or mass-produced parts.

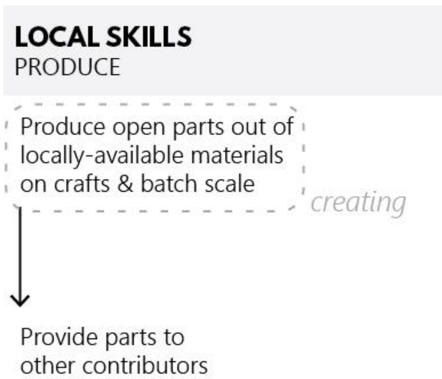

Figure 44. Flowchart for Local Skills for Production.

4.2.2. Initial Knowledge Sharing Considerations for Kitchen Practices

This section presents the last six considerations in Table 7, which are mainly focused on creating knowledge, sharing and adapting. They mainly present tips, cautions and processes on certain tasks during production, use and post-use of open parts and part assemblages. These considerations are not included in the design workshops, as this PhD study is concerned with the conceptual design of open, sustainable parts.

However, they are presented here as they surfaced through this analysis and they present important aspects of knowledge sharing in open, sustainable design process. These considerations can be used in real life open design processes to ensure the knowledge related to product/part longevity, personalization and post-use is conveyed among different contributors.

4.2.2.1. Informing Assembly

The way parts are assembled affects every aspect of open, sustainable design process, as it affects all other considerations deeply. When a contributor brings together parts, s/he has to be aware of the effects of assembly details on post-use processes (i.e. repair, reuse and upgrading) and disposal/recycling. For example, parts that need to be securely attached together should be attached so without glues or any other methods that result in permanent, irreversible assembly. Complex assembly details may present difficulties in accessing parts at a later stage as well, even though they are not permanent. On the other hand, other contributors should be able to access necessary materials and tools for assembly, and know how to perform the assembly properly and securely.

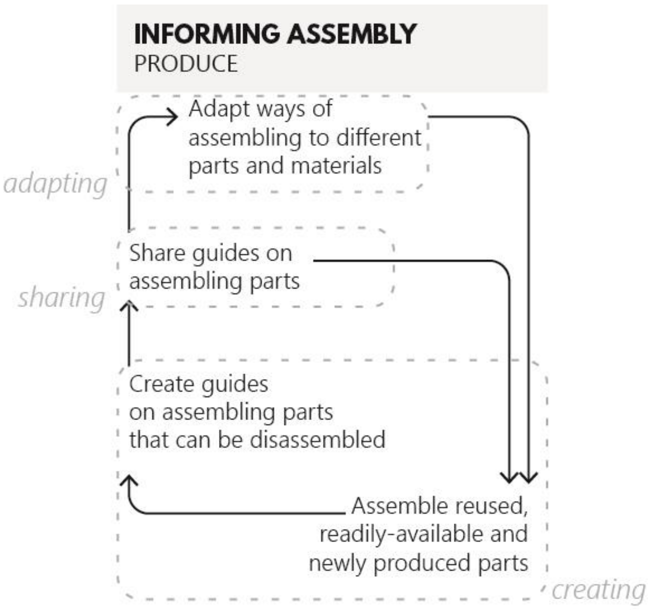

Figure 45. Flowchart for Informing Assembly.

Considering the above-mentioned concerns, *informing assembly* is an important consideration for an open, sustainable design process. Sustainability concerns of the study are dependent on the way parts are assembled together. It is essential that contributors know the way they should assemble parts and create assemblages of parts, for later being able to disassemble them. Participation scenarios for this consideration is depicted in Figure 45 and they are explained briefly as follows.

Creating and sharing new design-related knowledge: As mentioned above, the assembly of the parts in an open, sustainable design process should be performed without glues or any other methods that result in permanent assembly. However, it is not only about *sharing the steps of assembly processes*, but also about *giving information on the reasons for choosing a way of assembly*, *the tools and materials to perform the assembly*, *instructions on steps and various possibilities for other parts made from different materials* (i.e. readily-available parts or newly produced parts). Such detailed information creates the possibility for other contributors to reflect upon the assembly processes more holistically.

Adapting shared design-related knowledge: If the assembly process is shared as mentioned above, other contributors can adapt the knowledge for various parts they assemble, or the tools and materials they have. Adapting assembly processes can be about *finding better ways to assemble parts* or *sharing alternative ways to bring parts made of different materials.* If such adaptations are shared with other contributors as well, the alternative ways of assembly will become visible to everyone and more people can become able to perform the assembly in the proper way.

Implementing shared design-related knowledge: As mentioned before, sustainability concerns of the study are dependent on the proper assembly of parts. Implementing the shared knowledge on assembly is therefore crucial to ensure the longevity of parts through repair, reuse and upgrading.

A limitation of this consideration may be the dependency of other considerations throughout the life-cycle phases. This consideration concerns itself with the application of assembly techniques and affects the physical outcomes of the open, sustainable design processes. A failure in its implementation scenario hinders the sustainable solutions devised in the design phase.

4.2.2.2. Informing Use

Informing use is about how the physical outcomes of open, sustainable design processes will be – or should be – used to ensure product/part longevity, through informing the use phase in a cautionary fashion to prevent part failure and break down. For this consideration to be meaningful in the context of this research, various levels of information should be shared including simple explanations on basic cautions (e.g. do not use these blades for breaking ice) towards more explanatory and detailed information (e.g. the material used for the blades can only withstand X amount of hardness, any more than that would result in chipping on the blade). The levels of information to be shared is important for this consideration in order not to limit the use and reuse of parts for different kitchen practices other than the intended ones. According to the content of the shared information, the opportunities and constraints of open parts may remain unexplored. Other than the above mentioned, *informing use* consideration is wide-ranging with regards to its content and application. As an additional comment, this consideration is important due to the differentiated physical outcomes of the open, sustainable design processes. Unlike any mass-produced product, which goes through vigorous user and durability testing, the physical outcomes open processes are generally untested until use. Hence, I believe *informing use* is an important aspect of the open process, to inform contributors of possible outcomes and problems they may face during the use phase. In Figure 46, you can see how this consideration works.

Creating and sharing new design-related knowledge: The design of parts, the way they are produced and assembled together creates opportunities and limitations on their use phase, which are explored during the use phase. *Cautions about the ways of using, which result in part breakdown or excessive maintenance,* should be well documented and shared with people. However, as mentioned above, the information should be in different levels, from simple and understandable by everyone, to explanatory and detailed in order not to limit use explorations.

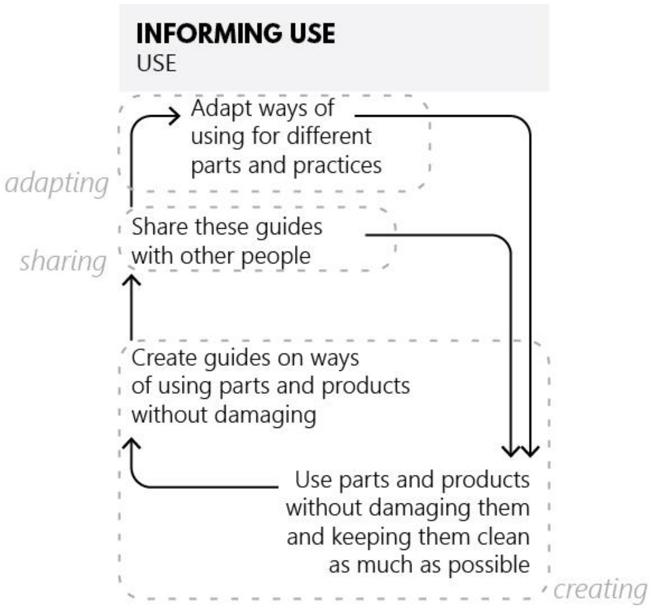

Figure 46. Flowchart for Informing Use.

Adapting shared design-related knowledge: The ways part assemblages are used differ for every kitchen practice and the people who are using them. Accordingly, such alternative ways of using explore different outcomes and present different limitations, which may render initially shared cautions obsolete or brings forward new cautions to be mindful of. Thus, sharing different, personalized ways of using can help other users to find out about alternative ways of using assemblages of parts, while preventing product failure and break down.

Implementing shared design-related knowledge: Initially shared or adapted ways of using should be implemented by other people to ensure longevity of the assemblages of parts they use. Through various levels of information (i.e. from simple and easy, to explanatory and detailed), other people can understand the limitations of their open design solutions and act accordingly.

4.2.2.3. Informing Disassembly

Disassembly of parts is closely related to their assembly – which is explained in informing assembly consideration – yet the act of disassembly presents further implications beyond simply retracing steps of assembly. First of all, it may not be necessary to disassemble the whole parts for post-use processes (i.e. repair, upgrading), or having to disassemble every part just to replace one of them may discourage undertaking post-use processes altogether. Consequently, informing disassembly is about creating and sharing different scenarios for reaching to different parts during post-use processes, and this consideration is closely related to *ease of disassembly* and *disassembly for maintenance* considerations explained in the design phase. Secondly, disassembling (or extracting) a certain part out of an assemblage of parts should be carried out without damaging other, adjacent parts. Ensuring other parts' longevity is the biggest challenge for disassembly, which makes it important to inform contributors of open, sustainable design process about ways of disassembling parts. In Figure 47, how this consideration plays out in open processes is shown, and the participation scenarios are explained briefly below.

Creating and sharing new design-related knowledge: Practice-oriented assemblages of parts created by contributors also require guides for disassembling them to ensure the individual parts can be replaced and/or reused. Such information should be generated to contain *several scenarios for individual parts* as well as *taking apart the whole assemblage*. Some complementary information is required too, such as *the necessary tools* to undertake the disassembly, *tips and cautions to keep parts safe*, and possibly *visual guides to convey the disassembly steps correctly* to other contributors.

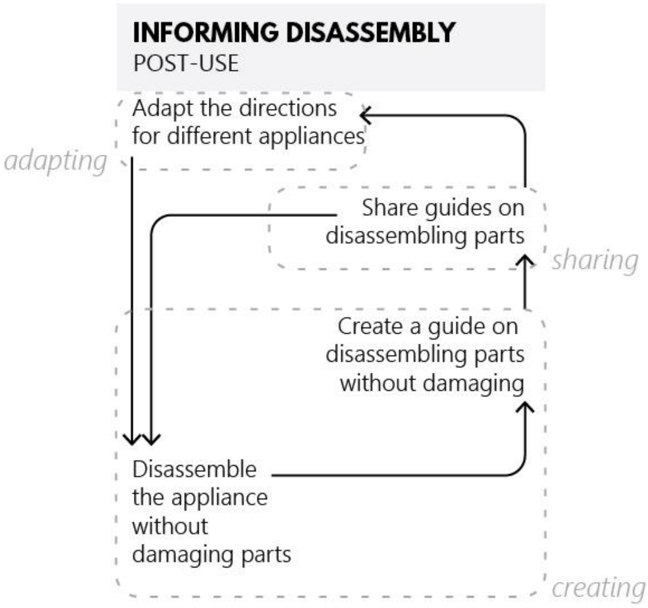

Figure 47. Flowchart for Informing Disassembly.

Adapting shared design-related knowledge: Shared guides for disassembly can be carried out *using different tools*, or *different ways of extracting specific parts* may be devised by other contributors. Adapting ways of disassembly develops the initially shared guides further, and expands their application for other contributors with different capabilities and different tools.

Implementing shared design-related knowledge: Implementing the shared knowledge about disassembly is important to ensure the longevity of adjacent-to-replaced parts. An assembly of parts may require skills and knowledge beyond an individual's own knowledge, and if the shared knowledge is constructed according to the above-mentioned properties, s/he can learn about tips, cautions, necessary tools, and how to perform the steps. Implementing helps disseminate the proper ways of taking apart assemblages of parts, eliminating unnecessary waste creation.

4.2.2.4. Informing Maintenance

Maintenance is an important aspect of objects used for kitchen practices to ensure the longevity of the parts used to prepare food. Different materials and surface details require different kinds of cleaning and maintaining, and some parts need to be protected against wear and liquid contact. Furthermore, the effects of improper maintenance may not be visible right away, yet harm the parts in the long run. Some transparent parts may become opaque, some other parts can become permanently stained. The necessary care to ensure part longevity varies according to the types of parts and the way they are used, and this knowledge needs to be conveyed to everyone using those parts. In addition, this knowledge should be clarified with the reasons to use certain techniques, the frequency of maintenance, and the materials for the maintenance, as well as how it prevents part failure. Figure 48 shows how this knowledge needs to be shared and the possible scenarios are also explained.

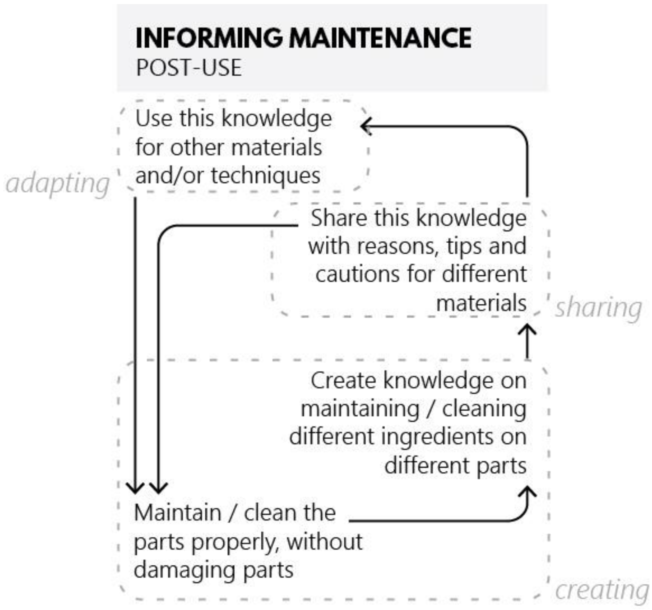

Figure 48. Flowchart for Informing Maintenance.

Creating and sharing new design-related knowledge: Due to the different kinds of ingredients used throughout the food preparation and cooking processes, the parts of open kitchen solutions may require different ways of cleaning and maintaining them. This knowledge should be generated alongside the design and production knowledge, and should be shared with everyone in a proper way. This knowledge should include *tips and cautions to clean/maintain certain parts* and inform users about the *long-term effects of improper maintenance*, which may not be visible immediately.

Adapting shared design-related knowledge: According to the generated knowledge on maintenance, users may find different, easier, or better ways of maintaining parts through a combination of their prior experience in using kitchen appliances. This knowledge should also be shared with other people to inform them alternative ways of maintaining parts, expanding the knowledge on maintenance.

Implementing shared design-related knowledge: Proper ways of maintaining that are shared should be implemented by users, through understanding the reasons for carrying out those maintaining processes after open solutions are used. The most important aspect of implementing shared ways of maintenance is through understanding the reasons for them. Through properly informing people, proper ways of maintaining can be adopted and implemented, elongating product/part lifespan.

4.2.2.5. Informing Repair

As an aspect of the product/part longevity and people's roles on it, the way broken or malfunctioning parts can and should be repaired is an important part of the knowledge that needs to be generated in an open design sharing context. There are two kinds of the information related to repairing: locating the malfunctioning parts, and repairing them. If such knowledge is provided, people (i.e. individuals, craftsmen, repairmen, etc.) can understand the problem about a part assemblage through the kind of malfunction, simple testing of parts, etc. After locating the malfunctioning parts and understanding the problem, the individuals can carry out the repair steps, or if it is too complex to handle, they can take the parts or part assemblage to a professional (i.e. craftsmen, repairmen). The generated knowledge on repair also helps professionals to properly carry out the repair processes, as it shows the reasons, tips and cautions for every step of the repair. This consideration is highly related to *Informing Disassembly* consideration, as a person first needs to disassemble the malfunctioning part and then repair it. Figure 49 shows the potential scenarios of generating and sharing knowledge in open design context.

Creating and sharing new design-related knowledge: Ways of repairing parts in relation to potential breakdown reasons, handling certain parts, necessary tools and skills, and so on, should be turned into guides that can be understandable by other people. These guides need to accessible to anyone who needs them, and inform them about *locating the problem* and *fixing it*. The assessment to locate the problematic parts and the steps of fixing them need to be explained in detail, along with detailed reasons for each step, so that this knowledge can be adapted to other parts and products as well.

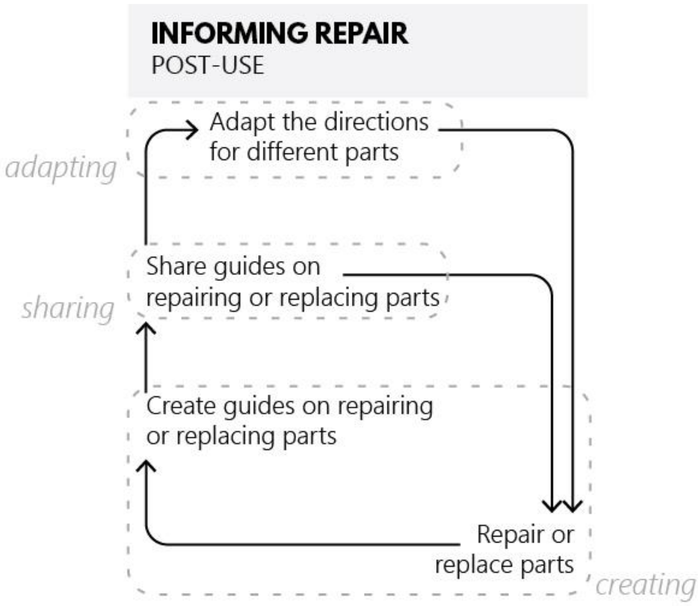

Figure 49. Flowchart for Informing Repair.

Adapting shared design-related knowledge: The guides created and shared by other people can be adapted to locate and fix problems of similar parts and part assemblages they have at hand. Shared knowledge, if it includes detailed reasons for each step as well as tips and cautions, can be altered by other people facing similar problems, or different ways of fixing the parts and part assemblages can be developed. Sharing the altered knowledge can expand the solution ground for repair processes.

Implementing shared design-related knowledge: Initially created and later adapted knowledge should be adopted by people (i.e. individuals, craftsmen, repairmen) to properly repair broken down parts and part assemblages. In this stage, individuals should have enough knowledge on necessary skills and tools to carry out the repair processes and decide if they can handle them. Should the individual decide that s/he cannot carry out the repair processes, s/he needs to outsource it to professionals (i.e. craftsmen, repairmen).

4.2.2.6. Informing Reuse

The decision to reuse parts has to be made according to the condition and compatibility of the salvaged parts to the next assemblage of parts it will be utilized in. Such decisions may require certain kinds of knowledge and/or expertise, which should be informed to individuals in an open process. This consideration is related to *Informing Disassembly* and *Informing Assembly* considerations, as a part should be disassembled from one assemblage of parts and assembled in another. This consideration is about assessing the usefulness of such a part and making sure that it can be reused in another assemblage. If the part is complex and/or require expert assessment, this task can be outsourced to a local producer. Such knowledge should include potential reuse scenarios for open parts in various contexts and for different uses. Figure 50 show the potential scenarios for *Informing Reuse*, and these scenarios are explained below.

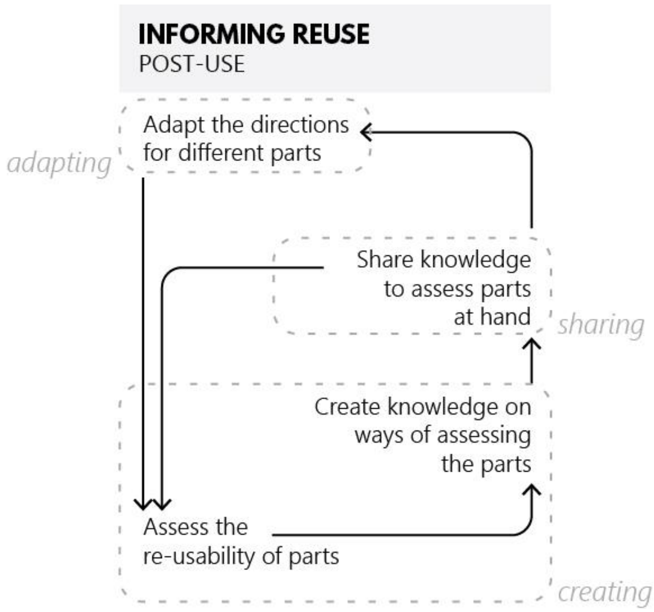

Figure 50. Flowchart for Informing Reuse.

Creating and sharing new design-related knowledge: Assessing the parts and reusing them for different purposes require different procedures for testing the usefulness of parts, as well as meaningful ways of reusing them to elongate their lifespans. Hence, the knowledge generated for reuse is two-fold. On the one hand, people need to know how to assess the parts and ensure they are still working and usable. On the other hand, different assemblages of reusing parts should be shared, so that people can reuse those parts that fits different needs and preferences.

Adapting shared design-related knowledge: Through understanding the capabilities of reusable parts, and different opportunities they may create, people can reuse open parts in different contexts and alter the way they are used. On the other hand, directions for reusing parts can be adapted to other similar parts to assess their usefulness. Such possibilities and alternative ways of assessment should be shared to expand knowledge on reusing open parts.

Implementing shared design-related knowledge: People who decide to reuse an open part should implement the shared ways of assessing that open part, understand the usefulness the individual part in different contexts and decide accordingly.

4.3. Understanding Open, Sustainable Design Processes for Kitchen Practices

In this section, flowcharts for sustainability concerns of the study (i.e. integrated scales, ease of maintenance, ease of repair, part reuse, and personalization) are presented in the form of flowcharts, using the design considerations developed throughout the analysis of existing concerns and explorations. The flowcharts in this section should be regarded as incomplete, since they only depict the projection of the analyzed content and do not necessarily represent the complete potentials of open design for sustainability. These flowcharts include the types of parts presented in the previous sections (i.e. individually or locally produced open parts, local retail parts and international supply parts) as well. These flowcharts can be considered as templates to be adapted according to the necessities, limitations and priorities of an open design project. The purpose of these flowcharts is to aid me throughout the analysis of the workshop outcomes, especially in building up and assessing the processes beyond the physical outcomes.

4.3.1. Open Design Process for Distributed Production

Distributed production is crucial for open, sustainable design processes as it expands the solution ground for contributors beyond their individual skills and knowledge. As can be seen in the flowchart below (Figure 51), the analyzed data at this stage of the study revealed two main considerations for design phase: (1) using-readily available parts and (2) standardizing assembly details. *Using readily-available parts* that can be acquired through local retailers is an important consideration, if the contributor requires to utilize properties of materials that s/he cannot produce with. The realization of such a need during the design phase enables the contributor to design other open parts accordingly, and readies him/her for the production and assembly of newly produced parts with readily available parts.

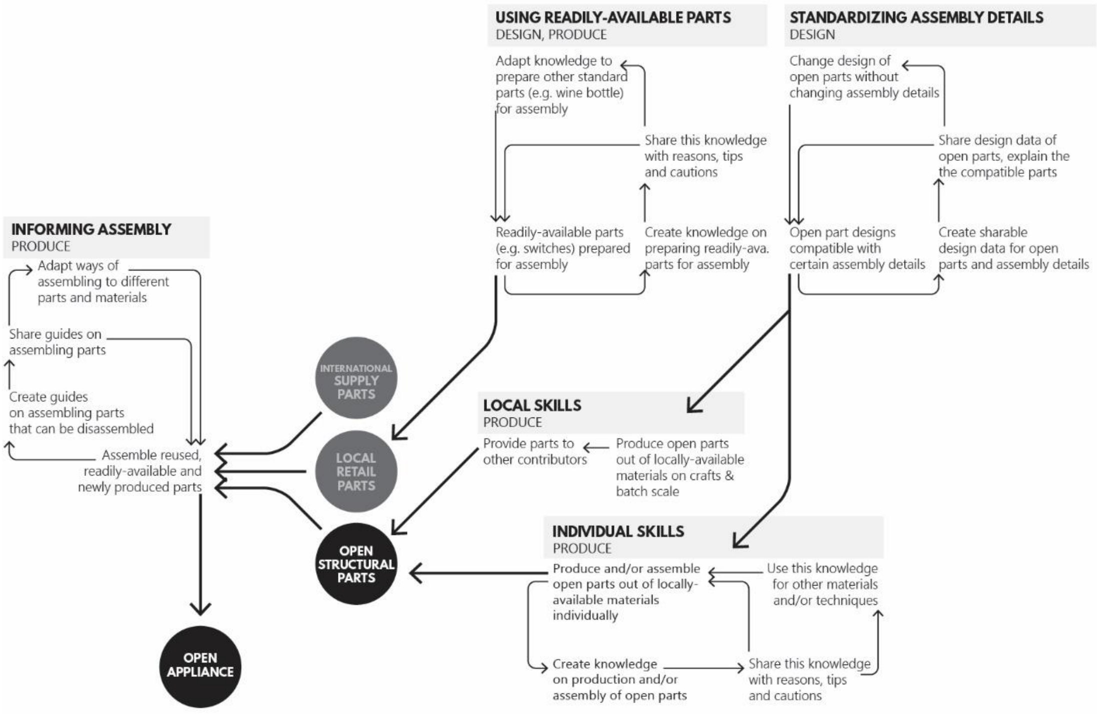

Figure 51. Flowchart for Open Design Process for Distributed Production.

This brings us to the second consideration for the design phase, which is revealed during the analysis. *Standardizing assembly details* of open parts is important to bring together these open parts and readily-available parts in different assemblages for different kitchen practices.

For the produce phase, there are two main options: acquiring parts that are produced by local craftsmen or batch-scale producers, or producing parts individually. For the local skills for production consideration, the flowchart continues in one direction, local producers provide the open parts and individual contributors acquire these parts. However, for the individual skills for production consideration, the individual not only produces the parts but also creates and shares knowledge on how to produce that part. Other contributors, then, can use this knowledge to implement the shared production techniques or adapt them for different parts, materials, etc. Within an open, sustainable design process, both local and individual production is considered to result in open parts. These open parts are then assembled with local retail parts (i.e. readily-available parts) and, if they are necessary, international supply parts. Informing assembly consideration comes to fore, as the contributor (e.g. individual, local craftsmen, repairmen, etc.) is expected to not only assemble the parts but also inform other contributors through sharing how the assembly of those parts are carried out. Through the assembly of parts, an open appliance is created.

4.3.2. Open Design Process for Ease of Maintenance

Ease of maintenance in open, sustainable design process involves considerations for design, use and post-use life-cycle phases, which are depicted in Figure 52. Maintenance for open parts and part assemblages stem from the need of cleaning and keeping clean those parts to ensure part longevity. *Cleanable surfaces* consideration is about surfaces that come into contact with food ingredients. Designing parts with surface details (or void of details) from which food remnants can be cleaned, and sharing the practical implications of these solutions with other contributors is important to create parts and assemblages of parts that can be used for extended periods of time. *Minimizing need for maintenance* consideration is about creating design details that prevent more than necessary dirtying of parts and/or kitchen environment. Design solutions that prevent splashes, spillages, overflows, etc. can be examples for this consideration, which directly affects the design of the parts. Sharing practical implications of such design solutions for the open part design at hand, enable other contributors to reflect on the part designs, implement the solutions directly or adapt them for different part designs. *Feedback on maintenance need* is about creating feedback mechanisms to enable the user of the assemblage of parts to understand when maintenance is necessary and sharing these solutions along with detailed explanations of the feedback kinds and the way they work. While different kinds of feedbacks can be designed and implemented, the solutions might be as simple as selecting the right materials for the parts.

Disassembly for maintenance affects both the design of the product and the maintenance scenario during post-use. It is about disassembling the assemblages of parts just for cleaning parts, especially when cleaning one part may harm another part (e.g. electrical parts). Hence, the scenarios of disassembling parts easily to a certain extent to enable easier and safer maintenance should be created, the design of the parts should respond to these scenarios, and these scenarios should be implemented by other contributors. Using these considerations, open part designs are created.

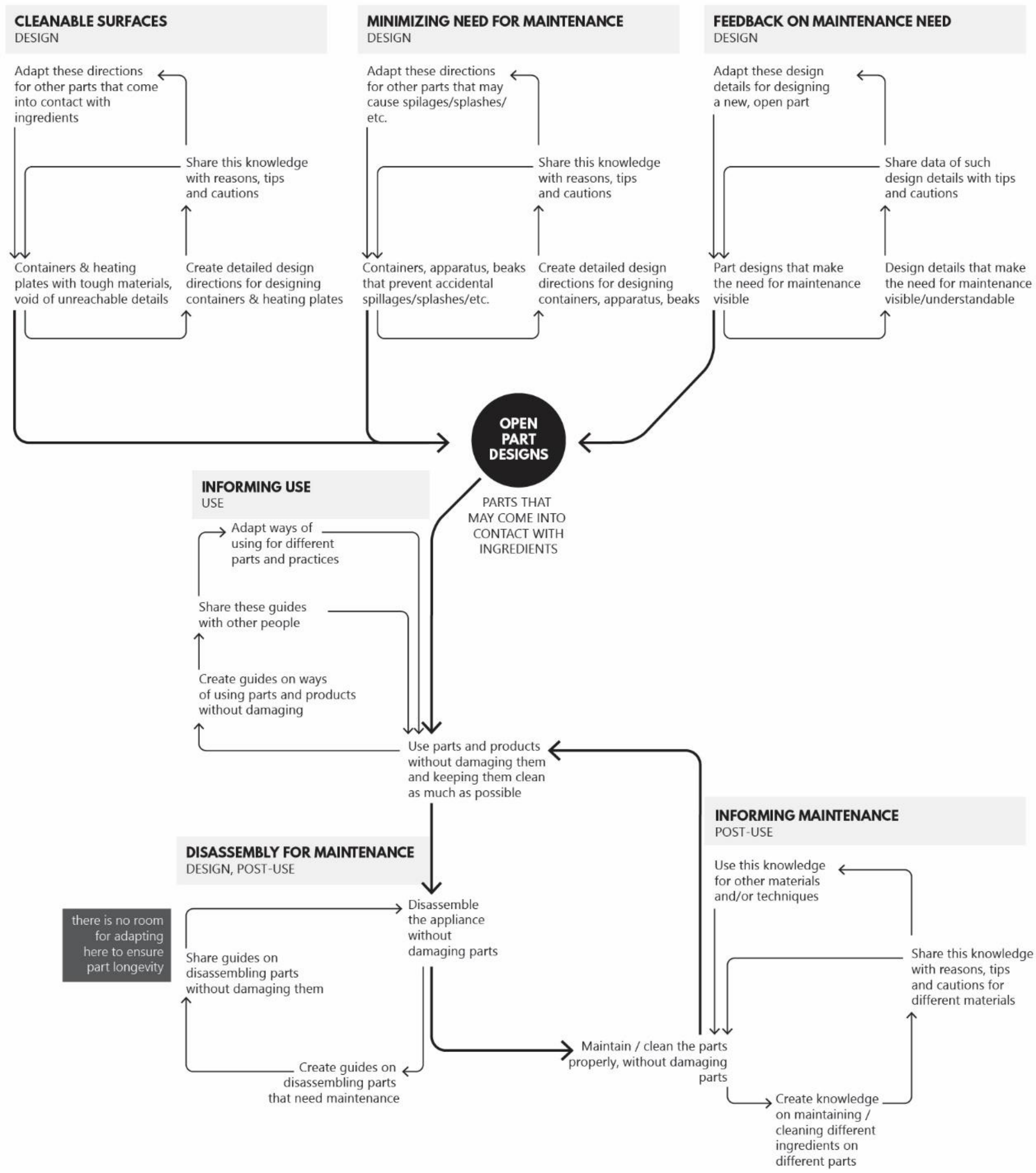

Figure 52. Flowchart for Open Design Process for Ease of Maintenance.

Informing use consideration is important for ease of maintenance of parts and ensuring part longevity. It is about sharing cautions and tips to prevent part breakdowns or extreme wear and tear during the use phase. Wearing on the surfaces that need cleaning makes the maintenance process harder, and in extreme cases, even impossible, resulting in part disposal. After use, the assemblage of parts can be disassembled for maintenance, if necessary, and cleaned for the next use. Informing maintenance consideration is also important in this step, as creating and sharing knowledge on how to clean parts made of different materials and how to remove different kinds of food remnants is necessary for the ease of maintenance.

4.3.3. Open Design Process for Ease of Repair

Ease of repair in open, sustainable design process involves considerations for design, production and post-use, which are depicted in Figure 53. For the design of parts, it should be noted that all open parts need to be designed keeping *ease of disassembly* in mind for the post-use processes. The ease of disassembly consideration does not only affect the parts designs but also how the parts should be assembled as well, hence it is related to *informing assembly* consideration for bringing together the open and other parts and to *informing disassembly* consideration when the parts need to be disassembled to be repaired. In addition, open parts have to comply with *standard assembly details,* which are either already existing or newly emerging, so that all the open parts can be brought together with different non-open parts. For ease of repair, it is important to include some kind of *feedback mechanism* to indicate the breakdown reasons, especially for non-open parts that people don't know how they function or why they breakdown. These feedbacks and their meanings need to be shared with people, so that they can take informed decisions on how to carry out the repair.

Upon the design and production of open and non-open parts, they are assembled together with other reused and/or readily-available open and non-open parts, resulting in an open appliance. As mentioned before, *informing assembly* consideration is key at this stage to ensure the future reparability of parts and part assemblages. If and when the open appliance breaks down, it is disassembled and repaired. Here, the tools and equipment, as well as the skills needed to carry out disassembly and repair needs to be clarified (i.e. informing disassembly and informing repair) to make informed decisions on who should undertake these tasks.

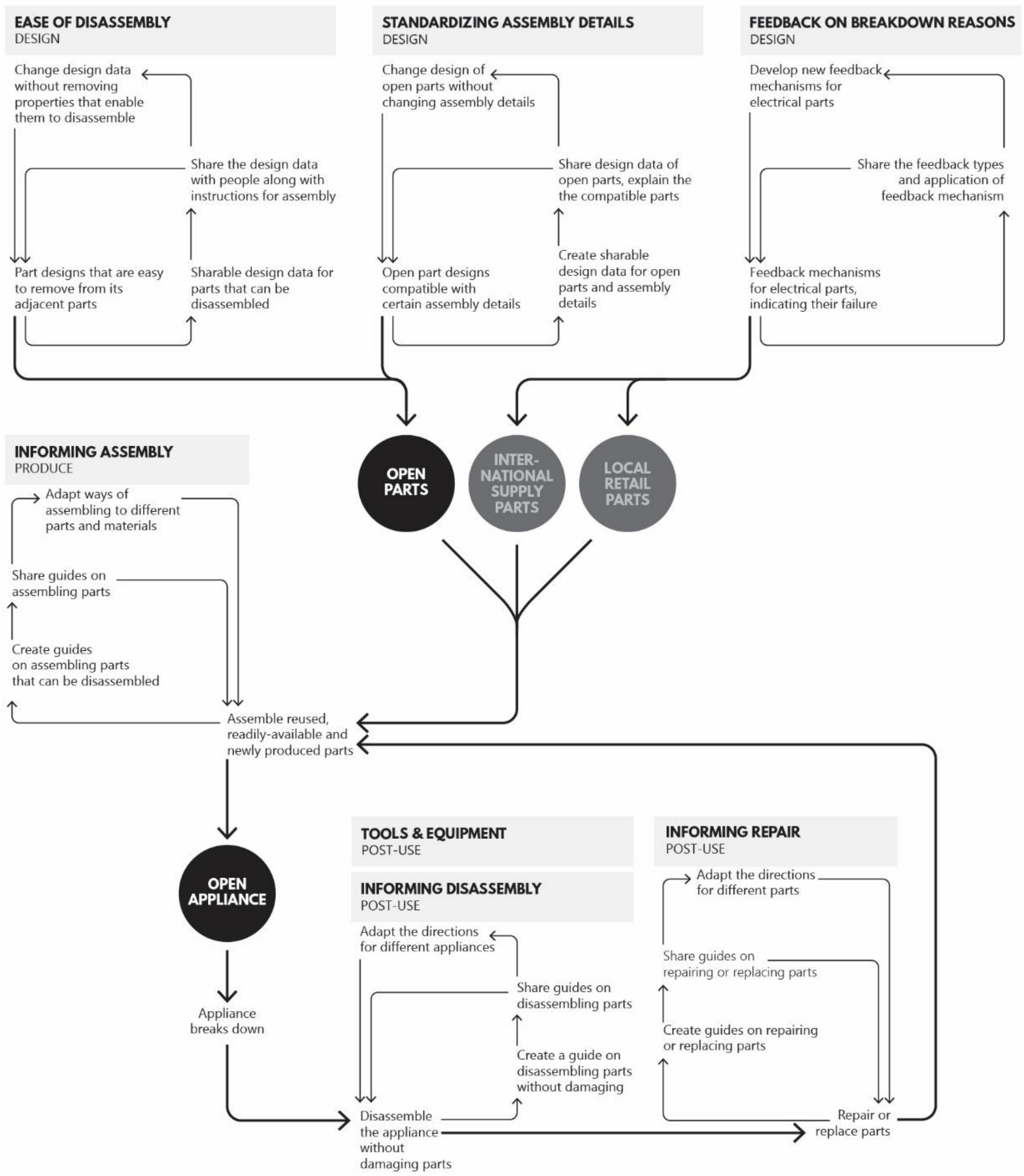

Figure 53. Flowchart for Open Design Process for Ease of Repair.

4.3.4. Open Design Process for Personalization

Personalization aspect of sustainability is not only related to the initial production of products, but also involves the upgradability and/or adaptability of them in post-use processes (Figure 54). As the needs and preferences of people change, the product needs to change accordingly to ensure part longevity. In an open, sustainable design process, this requires compatibility among open parts through *standardizing assembly details*. On the other hand, different open parts *responding to different needs and* *preferences* need to be developed as well. Since the design of open parts can be altered by anyone, parts of different shapes, sizes and materials can be developed by different people to be brought together with other open and non-open parts.

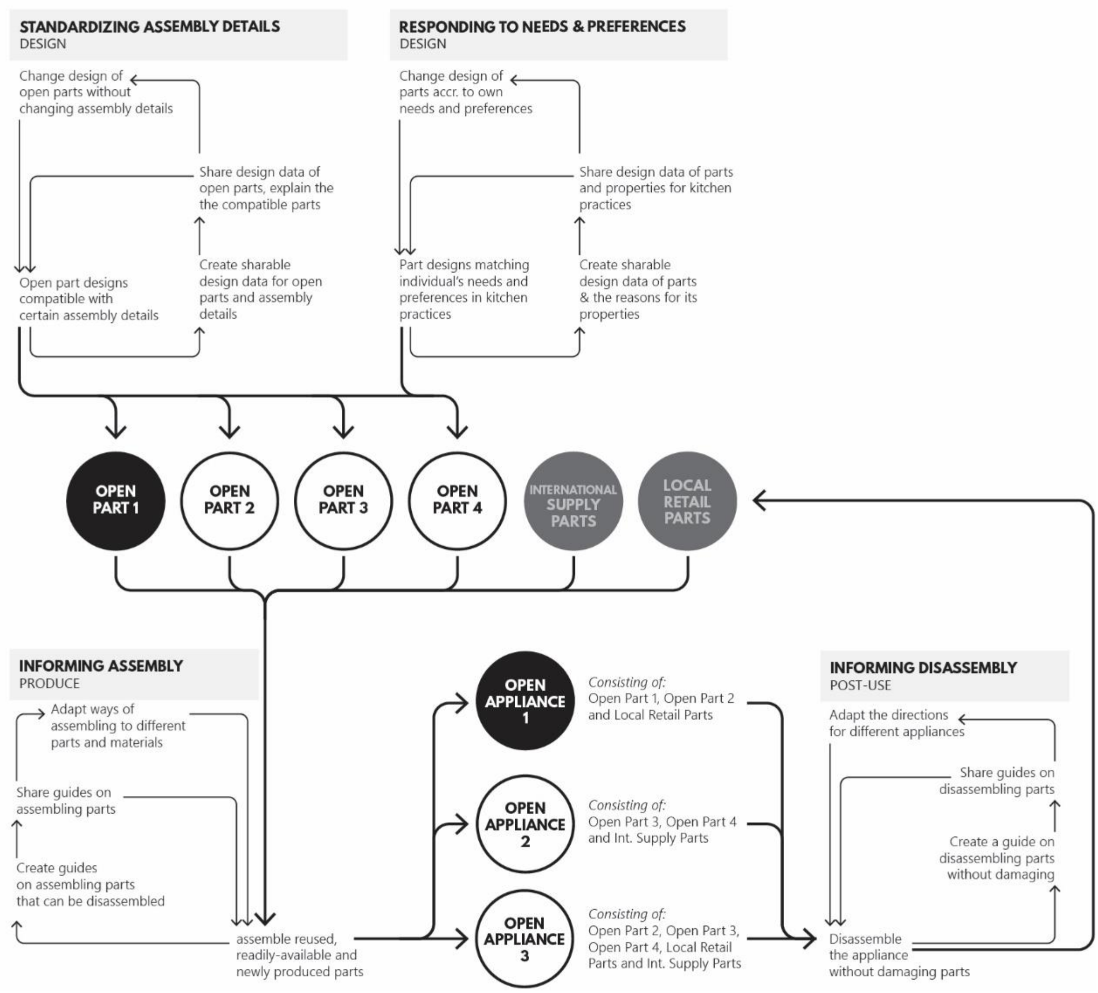

Figure 54. Flowchart for Open Design Process for Personalization.

It is important to abide by *standardized assembly details* while designing and producing these different parts, so that they can be brought together in different combinations. While bringing these parts together, informing assembly consideration comes to fore to ensure that different open parts are brought together properly to carry out their intended purposes in different part assemblages.

When people end up with a version of open appliance – among other possibilities – which is personalized, they use it until new/different needs and preferences emerge.

At this stage, instead of simply replacing the whole appliance, they can *disassemble* their existing open appliance and replace some parts with other open parts that *respond to their needs and preferences*. The open parts that are not used by one person anymore, can be used by another in a different part assemblage, as a part of another open appliance. On the other hand, the parts that are not replaced will be used further, ensuring part longevity.

4.3.5. Open Design Process for Part Reuse

The flowchart depicted in Figure 55 does not depict a process happening solely in an open design process, but also includes the integration of closed products into such a process. When an appliance breaks down, the initial purpose is to disassemble it (i.e. informing disassembly) and to try to repair it (i.e. informing repair). However, if it is hard, expensive or not worthwhile to repair the appliance, then the disassembled parts can be assessed to understand if they are reusable. At this stage, *informing reuse* consideration is very important as people will need to understand how to assess each and every part for their usefulness in another part assemblage. This assessment can be carried out by different people according to the varying complexity of parts – if it is a complex part that require additional tools for this assessment, a professional help is need.

The analysis revealed the use of readily available parts in addition to the reusable parts (i.e. using readily-available parts), which can be brought together with open structural parts that can accommodate them all (i.e. standardizing assembly details). These open structural parts need to be designed and produced locally or individually (i.e. local skills and individual skills), as they will need to accommodate the specific salvaged parts. In the end, all these parts are assembled together to end up with an open appliance.

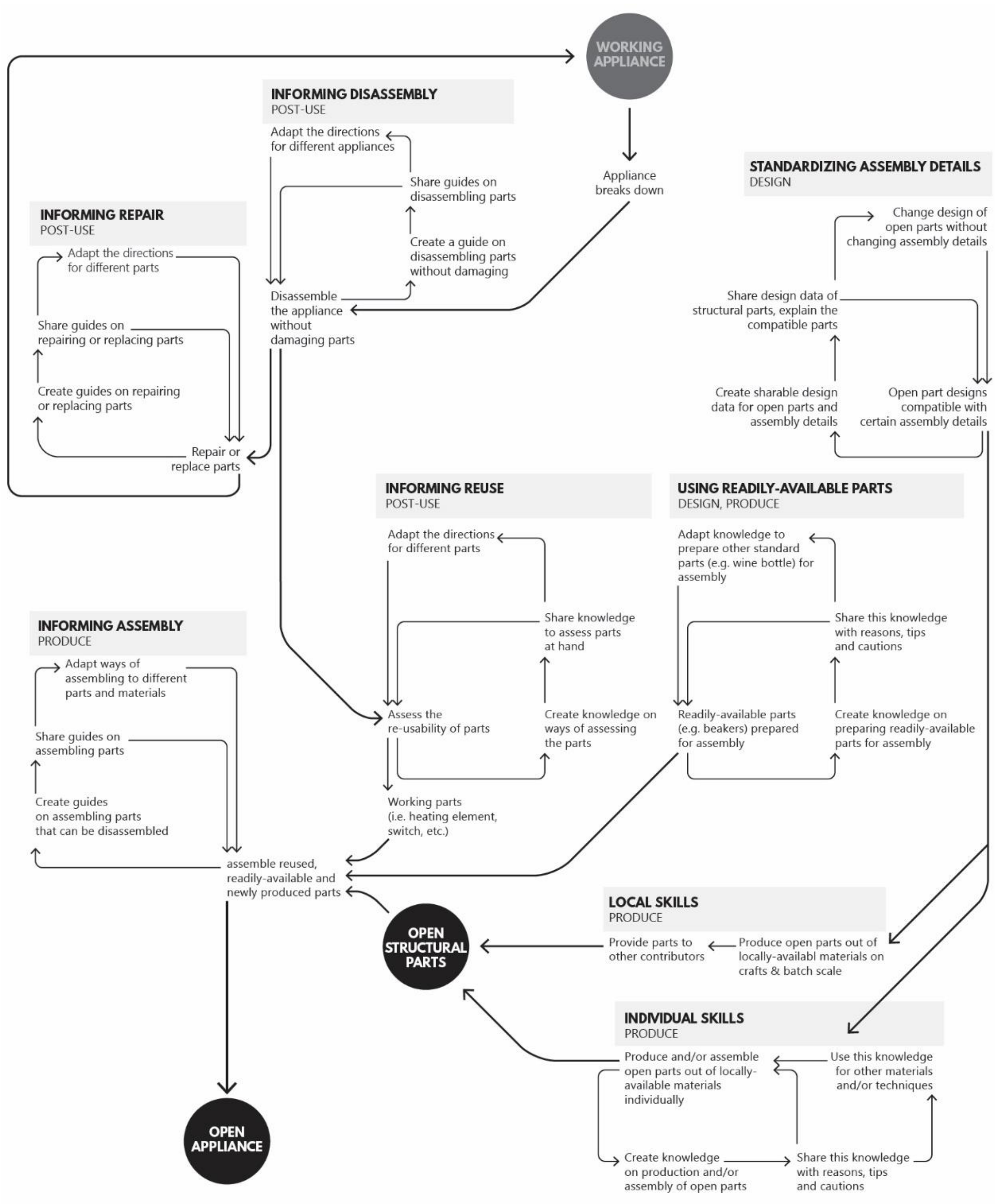

Figure 55. Flowchart for Open Design Process for Part Reuse.

4.4. Utilization of Outcomes in Further Stages

The purpose of the analysis of existing concerns and explorations was to create a theoretical background which can be adopted in the further stages of this study (i.e. design workshops) in a transferable way (i.e. transferable to the participants of the design workshops) and to found an informed starting point to understand the implications of open design process for sustainability in kitchen practices. The considerations at this stage are formulated to convey sustainability concerns on product/part longevity under the themes of personalization, part reuse, maintenance and repair, along with the obvious potential of open design on distributed production. The flowcharts for these themes were especially developed separately to avoid any immature, flawed unification of them – as the analyzed content could not offer such a comprehensive process addressing all themes at the same time. In the next chapters, through the two design workshops exploring two different part design-sharing patterns, I developed a more comprehensive open design process flowchart for sustainability in kitchen practices (see *Section 6.3.2. Flowchart of Sustainability Considerations and Part Properties for Open, Sustainable Design Process*).

As for the considerations, the ones directly related to the design practice will be addressed throughout the workshops, while knowledge sharing related considerations will not. This is due to the configuration of the *research through co-designing* methodology with design workshops and the time limitations of the PhD study. Knowledge sharing related considerations require a different way to be investigated, finding out how skill and experience related knowledge should be conveyed throughout open design process. This study, by its nature, investigates how parts and part assemblages should be *designed* in an open, sustainable design process. For this purpose, design-related considerations were integrated into the workshop structures with the help a generative tool, which will be explained in S*ection 5.1. The Structure of Workshop 1 and Generative Tools* Used and *Section 6.1. The Structure of Workshop 2 and Generative Tools Used*. As a result, a more comprehensive open design process flowchart is developed focusing more on the considerations that are explored in the following workshops. However, since the knowledge-related considerations are not incorporated in the workshops, the resulting flowcharts will only include design-related considerations and some aspects of production and post-use may not be covered in them.

CHAPTER 5

WORKSHOP 1: ITERATING OPEN SOLUTIONS FOR SAME PRACTICE

The first workshop was conducted on April 29, 2016, in NODUS Sustainable Design Research Lab, Aalto University, Helsinki, Finland. The workshop was open to all without any limitations on who can participate according to their professional and educational background. Although there were no limitations, the workshop topic was briefly explained in announcements and posters, which called out for participants that were interested in open design and sustainable design. Consequently, a total of six people attended the workshop, one of which wanted to remain anonymous while others agreed on sharing their personal information (i.e. names), so that I can use their names under their work and record the ownership of the ideas developed during the workshop (*see* Appendix B – Consent Form for the Participants of the Workshop 1). Although there was no limitation on background, the participants were from various design-related backgrounds (i.e. interaction design, service design, design history, design for sustainability). However, this does not limit the future use of developed design solutions: they can be used by anyone, anywhere, anytime.

An introductory presentation was necessary to communicate what open, sustainable design means – as advocated throughout this study (*see* Appendix G – PowerPoint Presentation Used in Workshop 1). Open design is a newly emerging topic in the design literature with wide-ranging definitions and/or assumptions like online collaboration, design data sharing, DIY, etc. Similarly, design for sustainability has wide-ranging concerns from LCA-based assessment of physical products to designing services and systems for social innovation. Thus, the participants are assumed to have different opinions on what open, sustainable design process means and how it works.

In order to inform the participants about the sustainability concerns of the study (i.e. product/part longevity, personalization, maintenance, repair, part reuse) and the open design process (i.e. creating, sharing, and adapting). The introductory presentation covered explanations for continuous open design process and the sustainability concerns of the study, as well as sustainable design considerations and generative tools (i.e. practice timelines, generative design toolkit, 3D posters).

Following upon the general introduction into the topic of the workshop, the theme (i.e. kitchen practices shaped around small kitchen appliances, e.g. pancake making, grilling sandwiches, etc.) was introduced along with a practice-based design approach and how to proceed with generating ideas through contextual scenarios. The participants were asked to focus on practices – rather than products – to steer them away from conventional small kitchen appliances and trigger idea-generation. Finally, the tools developed for the workshops were introduced, which are explained in the next section.

5.1. The Structure of Workshop 1 and Generative Tools Used

The sustainability concerns of the study (i.e. product/part longevity, design for personalization and design for post-use), their meanings and how open design can respond to these concerns were shared in detail with the participants at the beginning of the workshop through a half-an-hour presentation. Later, the participants were divided into three groups and three practices were selected: soup making, making pancakes and preparing salad. Figure 56 shows which group developed or iterated an open solution for which practice and at which stage.

The groups of participants exchanged part designs and practices; hence, at every stage every group had the chance to iterate the initial open design solution for their own needs and preferences. At the end of the workshop, three iterations of three different practices were created, showing if/how the initial design solutions were adapted by each group and if/how they responded the sustainable design considerations. However, creating and sharing design data for the next group to adapt them according to their needs, preferences and concerns in such a limited time requires generative tools and a well-structured process. Hence, this stage of the workshop followed the steps explained below.

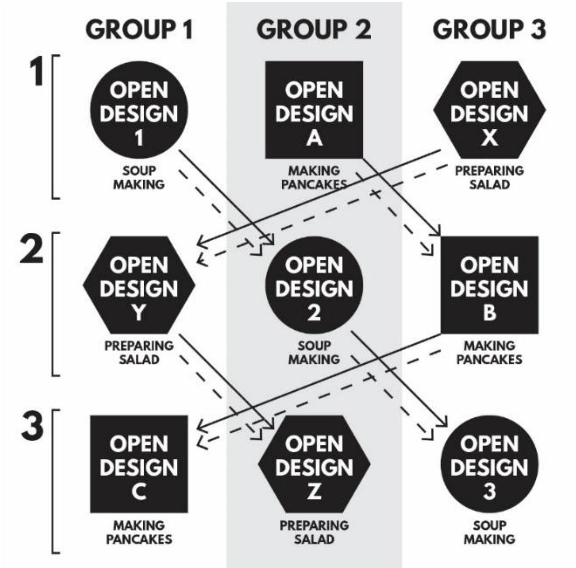

Figure 56. The structure of Workshop 1: Iterating Open Solutions for Same Practice, conducted in Helsinki, Finland (showing how groups exchanged open design solutions and practices).

Step 1: The participants were asked to choose a kitchen practice to develop an open solution according to their own needs, preferences and experiences, while keeping in mind the sustainability concerns of the workshop. Three kinds of generative tools were used in this process: Practice Timelines, Generative Design Toolkit and Sustainability Considerations Cards.

Practice Timelines are empty timelines that help participants to recall and reconsider the kitchen practices they selected. Through facilitating such a process, this tool aims to trigger idea generation in two steps. First, the participants recall their own version of the kitchen practice and write down each step of it. Then, they can reflect upon the practice through the sustainability concerns of the study and devise a new version of the practice below their current one (Figure 57).

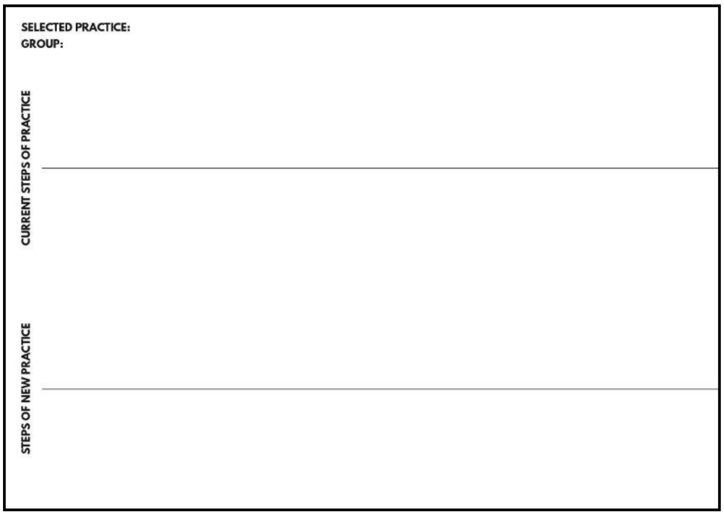

Figure 57. An example of the empty Practice Timeline provided during the Workshop on Personalization.

Figure 58. The Generative Design Toolkit for the workshop, readily available parts and mock-up materials (left) and representational electrical parts (right).

The Generative Design Toolkit consists of representational, laser-cut, cardboard pieces (i.e. motors, rotating levers, heating elements of various kinds, etc.), mock-up materials (i.e. cardboards, acetate sheets, modelling boards, doughs, tapes, scissors, etc.) and readily available parts (i.e. jars, bins, cans, etc.) as seen in Figure 58. This tool emerged from Experience Reflection Modelling (ERM) method, which uses a generative toolkit of representational parts made out of cardboard (Turhan, 2013), which is based on Velcro modelling (Sanders, 1992). In ERM, the generative toolkit is used to reveal users' thoughts and preferences that might be difficult to communicate verbally (Turhan, 2013). In this design workshop, the generative toolkit was developed further with the inclusion of representational electrical parts (i.e. motors, heating elements) and readily available parts, in order to make it easier to create physical mock-ups of design solutions throughout the workshop. The participants can use the representational pieces or they can adapt them according to their needs and preferences through cutting, taping new parts, etc. They can also create new parts out of the mock-up materials provided.

Figure 59. Sustainability Considerations Card for Disassembly for Maintenance.

Sustainability Considerations Cards are created to assist the participants during the idea-generation. Each card has one open, sustainable design consideration (see *Section 4.2.1. Initial Design Considerations for Kitchen Practices*) along with a simple explanation on the backside of the card (Figure 59). These cards were prepared for each emerging design related consideration developed in the *analysis of existing concerns and explorations*, and a set of cards was prepared for each group. The explanations on these cards were kept simple in order not to limit the participants through idea-generation. All the cards can be seen in *Appendix C – Print-Ready Consideration Cards for Workshop 1*. This step of the workshop lasted around 45 minutes.

<u>*Step 2:*</u> In this step, each group presented the open, sustainable design solution they developed along with the design considerations they adopted, important design decisions they made and how these were reflected in the design details. 3D posters were used as *a sharing medium*, through which they wrote down notes about their design decisions and linked them to the design details (Figure 60).

3D posters helped participants convey their decisions to other groups, while on the other hand they helped me document the physical outcomes and the related decisions through this shared template. Participants were also encouraged to use sustainable design consideration cards for these posters. Hence, these posters (or the images of them) were useful throughout the analysis of the workshop at the end.

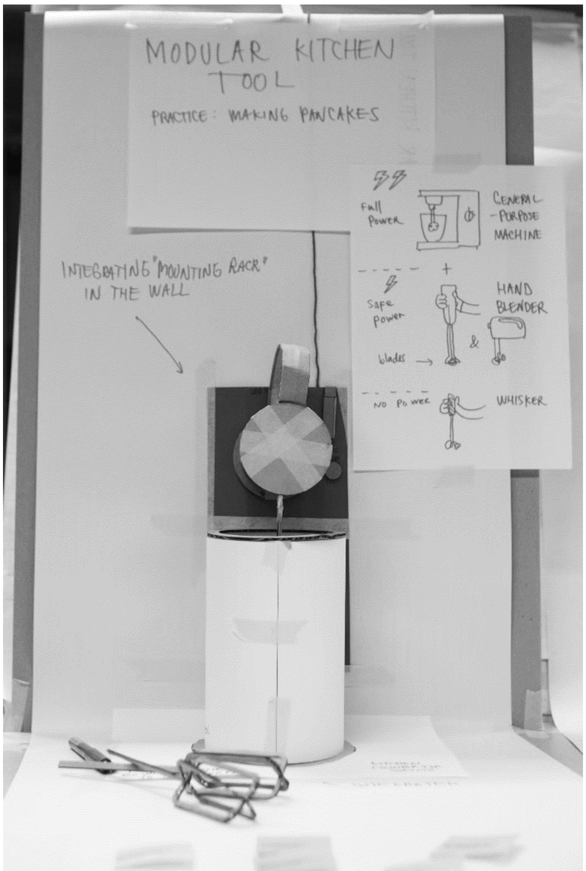

Figure 60. An example of 3D posters used in the workshop (a wall-mounted modular kitchen tool developed initially for making pancakes).

<u>*Step 3:*</u> Upon presenting the open, sustainable design solutions, each group took on another practice along with the initially developed design solution for that practice. Following the previous steps (i.e. Step 1 and 2), each group iterated the initial open, sustainable design solution using the same tools, according to their own practices and concerns. They were also asked to take into account design considerations that were not addressed in the previous design solution as well. These steps were repeated until at least three versions of the design solution were developed.

5.2. Outcomes of the Workshop 1

In this section, the outcomes of the workshop and their analysis with respect to design considerations and open part properties are presented. For every iteration, what the participants intended are given, and then the open parts that were designed for that iteration are shown and explained. Following the explanation of developed solutions, the part properties and how they respond to sustainable design considerations are explained. Upon presenting every iteration for a practice, an analysis on how the open design process responds to the concerns of the study through changing parts among iterations is presented. Finally, the results of the analysis of all three practices are brought together with sustainable design concerns and open, sustainable design flowcharts developed before in *Analyzing Existing Concerns and Explorations chapter*. The chapter is concluded with a reflection on the workshop process, the outcomes and the implications of open design process for sustainability. Since the open part properties emerged in this workshop, the open part properties and their definitions are presented in Table 8. These definitions will help to understand the illustrations prepared for each iteration, as well as the sections after that.

Table 8. Open part properties emerged in Workshop 1 and their definitions.

One-direction assembly	Parts designed to be assembled from one-direction, which can be disassembled in the opposite direction.
Generic assembly details	Off-the-shelf assembly parts (e.g. screws, nuts, buckles, etc.), assembly details (e.g. jar lid screws, caps, etc.) or details with no specific features (e.g. slits, holes, etc.)
Adapters	Parts that are used to bring together two different parts that do not have matching assembly features
Contextual	Parts that can be used for different purposes in different contexts (e.g. using the same part for cooking & eating)
Output Adjusting	Parts that enable changing the output of electrical parts (e.g. motor rpm, or temperature setting). This feature can be embedded in the electrical part itself, or an additional part can regulate the output.
Transforming	Parts that can change the kind of the practice that is carried out by the open solution (e.g. Chinese soup to blended soup)
Practice-related details	Details that are specifically developed for the practice in question (e.g. pancake scaling lines –not litres– for pancake making)
Conditional	Parts that can be used in an open solution under certain conditions (e.g. if the container is not heavy, you can use a single, long handle)
Multi-functional	Parts that are *designed* to be used for different purposes in a practice (e.g. removable pan handle that can be used to hold an oven tray)
Simple Forms	Forms and surfaces with basic geometry, which do not have intricate and hard to reach details (e.g. slits, holes, etc.),
Temporary attachment	Parts that can be removed from the open solution with simple movements, yet can be placed firmly enough to operate (e.g. removable pan handle)

5.2.1. Open Design Solutions for Soup Making

5.2.1.1. Initial Solution for Soup Making

The initial solution for soup making practice was focused on developing a solution that accommodates both Chinese and other ways of soup making. The group who developed this solution consisted of two members, Tianshi Shen - Chinese national living in Finland - and one other participant who wanted to remain anonymous. Since Chinese soups include fried ingredients (e.g. meatballs) and boiled vegetables, this practice normally requires a frying pan and a pot to boil vegetables in and finalize the soup. On the other hand, other soups may require the blending of ingredients through mashing them into a watered-down pulp. Hence, they wanted to develop a solution that would accommodate both of their soup making practices, and came up with open design solution in Figure 61.

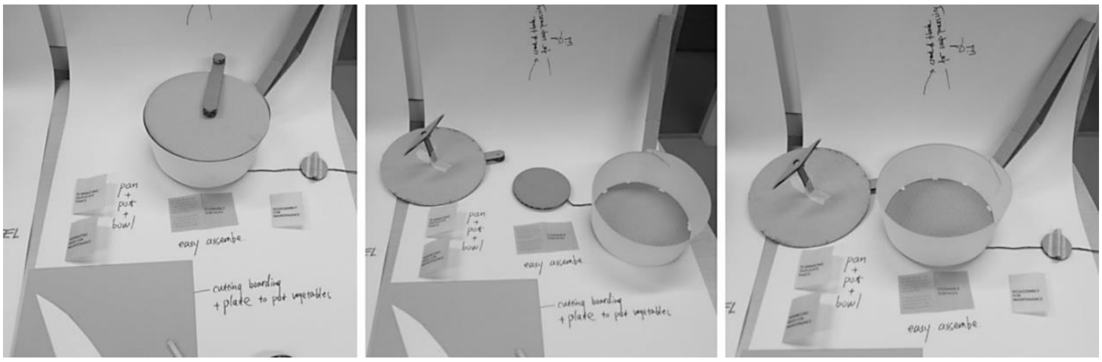

Figure 61. 3D poster of initial open solution for Soup Making, by Tianshi Shen and anonymous participant.

The parts and design details of the initial soup making solution are illustrated in Figure 62. The cooking vessel is designed in a deep yet widening, truncated cone shape to accommodate both frying and boiling water. A single handle is attached to it to enable ease of movement, like in a frying pan. An electrical heating base is located under the cooking vessel, on which the vessel can be easily positioned. The electrical heating base is equipped with an electrical cord that has an adjustment knob on it. The adjustment knob is used to regulate the heat coming from the heating base. The lid accommodates a crank arm and a blending apparatus with a two-sided blade, both of which can be removed. During soup making, the ingredients can be chopped and prepared on the cutting board with a chef's knife. The chopsticks can be used for both stirring the soup while cooking it and then later for eating the larger pieces of vegetables and/or meat.

The *multi-functional* form of the cooking vessel, a truncated cone, eliminates the need for two different cooking vessels: a pan and a pot. This was developed upon seeing the *eliminating duplicate parts* consideration card, however another potential of it was also revealed as *minimizing need for maintenance*: there will not be two different cooking vessels to clean later on. Although *eliminating duplicate parts* consideration emerged from the use of several electrical parts in the kitchen environment, like heating elements and motors, it now expands to non-electrical parts and affects other considerations as well. The participants also mentioned that this truncated cone form of the cooking vessel responds to their own needs and preferences, especially the Chinese way of making soups, however different forms can be developed to *respond to different needs and preferences*.

The crank arm and blending blades *transform* the whole solution to *respond to other ways* of making soup. Simply adding open parts (i.e. crank arm and blades) to this assemblage enables the blending of ingredients and different kinds of soup can be made later on. Such *transforming open parts* enable the use of the open solution in different cultural contexts and/or local needs and preferences.

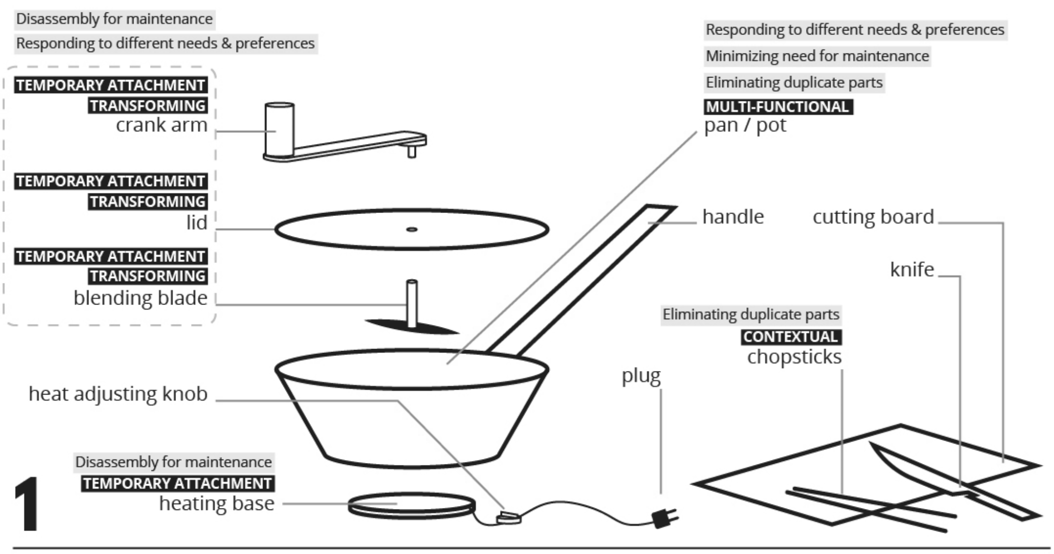

Figure 62. Illustration of the initial open solution for Soup Making, by Tianshi Shen and anonymous participant.

In this open solution, some parts need to be *disassembled for maintenance*. The heating element needs to be separated from the cooking vessel, so that water will not damage the electrical part and/or reduce its lifespan. On the other hand, the lid, blending blade and crank arm need to be separated to be handled and cleaned safely and properly. For this purpose, the participants used *temporary attachment* details: (1) the cooking vessel is simply taken of the heating element and (2) the crank arm, the lid and the blades are separated as shown in Figure 62. Here, the decision on which parts need to be disassembled is important. It is not simply separating the electrical part (i.e. heating element) to prevent any water damage, but also handling the parts properly and safely comes into question. Cleaning and drying an oddly shaped crank-lid-blades component seemed hard to the participants, hence they decided on disassembling them.

Finally, the use of the chopsticks in this solution presents a different property for open parts. The material for chopsticks (generally wood) and their form (long sticks) enable them to be used for stirring the soup while cooking – this was stated by the participant as a common, daily practice. Hence, they *eliminate the need* for an additional stirring spoon. On the other hand, the chopsticks are used by the participant to eat big pieces of vegetables and meat later on. The focus here is not on the cultural implications of chopsticks, or advocating their usefulness for kitchen practices. The focus is on how an open part can be utilized in different *contexts*, in this example, while cooking and then later eating.

5.2.1.2. 2nd Iteration for Soup Making

The second iteration was developed by Lilli Mäkelä and Outi Mustonen, who were concerned more on developing the initial idea to better respond to use and maintenance needs of the solution, while reflecting their own needs and preferences on the open solution. They mentioned that some baked ingredients (e.g. crunchy vegetables) could be added to soup later, and wanted to reflect this need/preference on the open solution (Figure 63).

Figure 64 shows the new and/or different parts in the 2nd iteration. Fixed handle in the initial solution was replaced with a removable handle solution. The cutting board is made out of silicone, foldable and can turn into an oven tray. The openings on the cutting board/oven tray is for the removable handle, which is used to put it in and take it out of the oven, as can be seen on the right end side of Figure 63.

Figure 63. 3D poster of the 2nd iteration for Soup Making, by Lilli Mäkelä and Outi Mustonen.

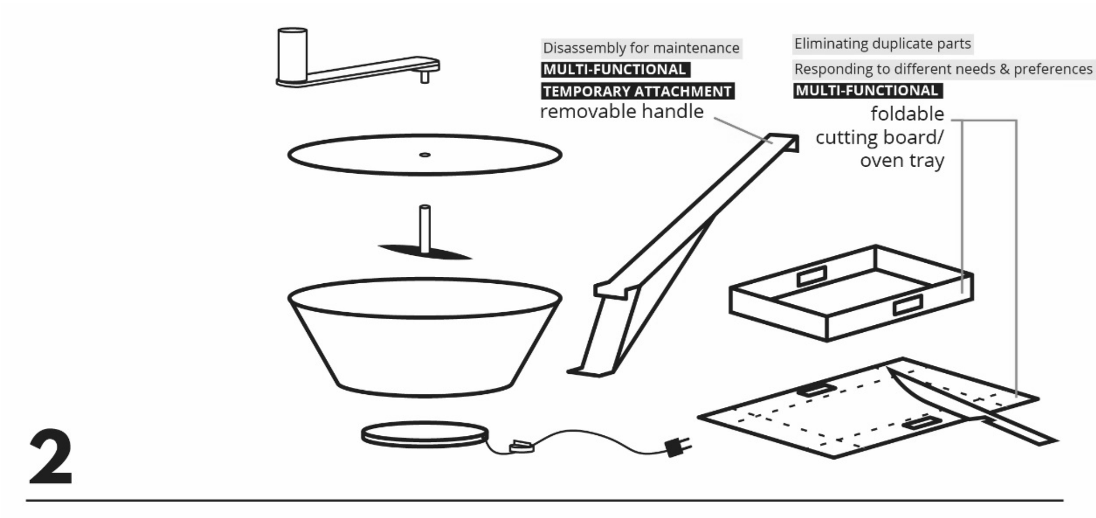

Figure 64. Illustration of the 2nd Iteration for Soup Making, by Lilli Mäkelä and Outi Mustonen.

The removable handle eases the maintenance of the cooking vessel, as that part can easily be put in a dishwasher after each use. The decision for this solution comes from the participants own experiences with pans and pots and putting them in a dishwasher. A long handle makes the pan/pot hard to place in a dishwasher rack, whereas *disassembling* the vessel and the handle eases the maintenance processes.

The cutting board in the initial solution is replaced to *respond to* participants' preferences on putting baked ingredients (e.g. vegetables) in soups, by a *multi-functional* silicone one. Through producing the silicone sheet in a foldable form with folding lines, this part *eliminates the need* for an additional oven tray to bake these ingredients. Since the handle is *temporarily attached*, the participants proposed that the handle could be used for different purposes as well through a *multi-functional* form. In this open solution, the cooking vessel handle is also utilized to handle cutting board/ oven tray. The participants saw the opportunity for utilizing a removable handle for similar purposes, as its form is useful in different purposes: handling a pot and handling an oven tray. However, it should be noted that, this property of the removable handle does not directly respond to any consideration. It is simply an added, practical functionality, which can be regarded as a part of the more general personalization aspect of open design.

5.2.1.3. 3rd Iteration for Soup Making

This iteration was developed by Emma Berg and Maria Mercer, who were concerned about the size of the cooking vessel. Their soup making practice includes making larger portions of soup, reheating, and consuming it over a longer period of time. On the other hand, they do not feel the necessity to fry ingredients (e.g. meatballs) prior to boiling vegetables. Consequently, they developed the solution in Figure 65.

Figure 65. 3D poster of the 3rd Iteration for Soup Making, by Emma Berg and Maria Mercer.

The new/different parts of this iteration are shown in Figure 66. The pan/pot used in the previous iterations were replaced by a bigger pot to *respond to* cooking bigger portions of soup. Instead of a single long handle, double sided smaller handles were used. In addition, the cutting board is replaced by microwave steamer/cutting board.

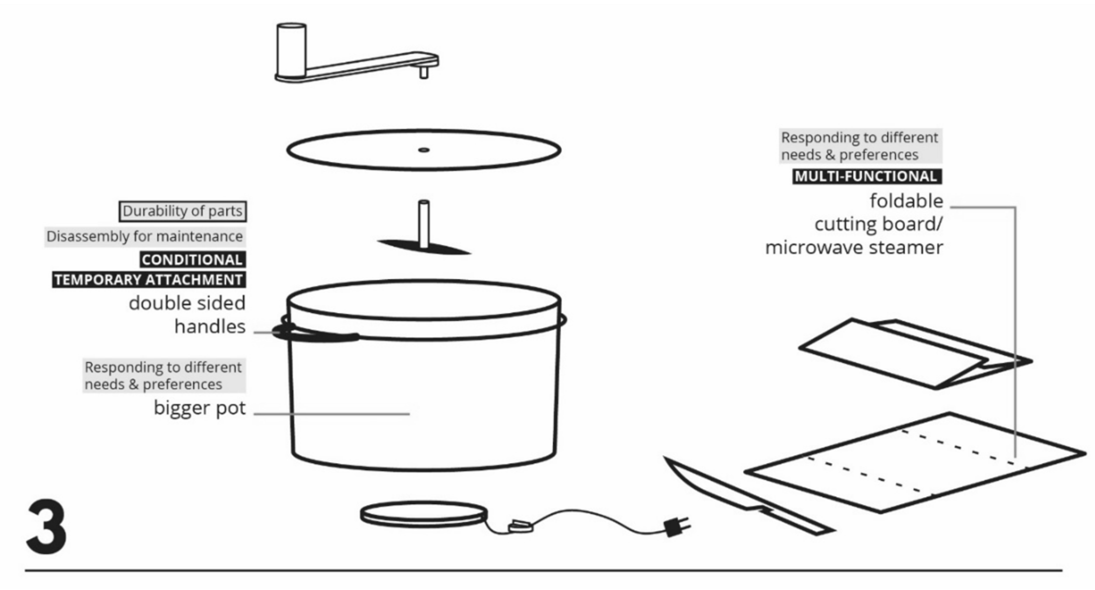

Figure 66. Illustration of the 3rd Iteration for Soup Making, by Emma Berg and Maria Mercer.

Changing the cooking vessel size and form made it heavier when it is filled with ingredients. Thus, the participants decided to change the handle as well, as one handle is not enough to carry the vessel properly, and may break down while the pot is full. The decision-making process the participants went through is important to ensure part longevity and actually brings forth a new consideration for open, sustainable design: *durability of parts*. Their iteration brings forth a *condition* for designing and bringing together open parts: "Double-sided handles should be used if the cooking vessel is bigger than a certain size." This *condition* makes it safer to use the design solution and help elongate its lifespan. However, the participants also adapted the *disassembly for maintenance* solution in the previous iteration and designed a *temporarily attached* handle ring for the handles to be removed for easier placement in the washing machine, and later, in cupboards.

Developing the cutting board for a completely different practice (i.e. steaming vegetables) is an interesting decision here. The participants do not need any microwave steamer for their soup making practice; however, they chose to adopt the *multi-functional* possibility of it from the previous iteration and utilize it for some other practice they frequently use in the kitchen.

5.2.1.4. Reflections on Open Solutions for Soup Making

Overall, designing and redesigning these open design iterations can be observed through the parts that were changed, added or removed with every iteration. Table 9 lists the open parts designed, other parts and kitchen utensils used in every iteration and how they changed among iterations. The part property columns are to indicate the property of the open part that responds to open, sustainable design considerations. The dark gray cells on the table indicate the open parts that were changed or added, and the light gray cells show the parts that were abandoned.

Table 9. Open Parts designed and other kitchen utensils used for soup making.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Truncated Pot/Pan	Multi-functional	Truncated Pot/Pan	Multi-functional	Bigger Pot	-
Fixed Pan Handle	-	Removable Pan Handle	Temporary Attachment, Contextual Parts	Removable Double-sided Handles	Temporary Attachment, Conditional Parts
Cutting board	-	Cutting Board/Oven Tray	Multi-functional	Cutting Board/ Microwave Steamer	Multi-functional
Chopsticks	Contextual Parts	-	-	-	-
Crank Arm/ Blades	Transforming Parts, Temporary Attachment	Crank Arm/ Blades	Transforming Parts, Temporary Attachment	Crank Arm/ Blades	Transforming Parts, Temporary Attachment
Heating element	Temporary Attachment	Heating element	Temporary Attachment	Heating element	Temporary Attachment
Chef's Blade	-	Chef's Blade	-	Chef's Blade	-
Knob Switch	-	Knob Switch	-	Knob Switch	-

As can be seen in Table 9, the cooking vessel, the handle and the cutting board changed among iterations. The truncated pot/pan responded to different ways of cooking required for Chinese way of making soup, while it was then replaced by a bigger pot in the 3rd iteration as those participants do not need to fry ingredients and they prefer to make larger portions of soup. But, just changing one part (i.e. cooking vessel) does not make the iterated solution complete, as there are also conditional parts (i.e. handles) that need to be changed in accordance. A pan handle is not suitable for handling a large pot; hence, it needs to be replaced with double-sided pot handles as well. On the other hand, the change from a fixed handle to removable handles is a different preference for a different stage of the practice: maintenance and storing. The removable pan handle was thought to ease the cleaning process by making it suitable for dishwasher, as the participants developed the 2nd iteration use a dishwasher in their daily lives. On the other hand, the removable double handles in the 3rd iteration makes it easier to store among other pots in different cupboards.

Table 10. Design Considerations used for Soup Making Practice in Workshop 1.

Design Consideration	**Initial definition from the analysis of existing concerns & explorations**	**Implications for explorations on soup making in Workshop 1**
Eliminating duplicate parts	reducing the number of electrical parts (e.g. heaters, motors, switches, etc.) which are placed in different appliances for different practices.	reducing the number of non-electrical parts through creating <u>*multi-functional*</u> forms (e.g. truncated cone shaped cooking vessel) or <u>*contextual parts*</u> (e.g. removable pan handle/oven tray handle).
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and kitchen environment	a reduction in the number of parts used to carry out a practice also reduces the number of parts to clean/maintain
Disassembly for maintenance	Disassembling parts for cleaning/maintenance. For some parts, they need to be disassembled so that surfaces that come into contact with ingredients can be reached. For others, they are positioned close to the electrical parts and they should be separated to prevent water damage.	enabling the maintenance of parts (e.g. lid, crank arm and blades) and separating electrical and non-electrical parts to prevent water damage to electrical parts (e.g. heating element) by bringing them together with <u>*temporary attachments.*</u>
Responding to different needs & preferences	Different parts that respond to the changing needs and preferences of different people should be able to be brought together, resulting in different and flexible assemblages of parts.	Responding to changing needs and preferences of different people through <u>*transforming*</u> parts that are included in the part assemblages.
Durability of Parts	-	Deciding on how to iterate related open parts according to <u>*conditions*</u> (e.g. bigger pot requires double handles) that apply to those parts.

The changes in the cutting board are driven by different purposes as well. In the initial solution, the cutting board is simply a needed element throughout soup making process. In the 2nd iteration, participants saw an opportunity to create a small oven tray out of it to better respond their own soup making practice – as they bake some vegetables and add them to their soups. However, in the 3rd iteration, the purpose is respond to a different practice beyond soup making and the cutting board can transform in a microwave steamer. The participants who developed the 3rd iteration do not bake ingredients, yet they felt the need to develop the cutting board into something they would use in the kitchen.

These changing open parts throughout the open design process provides various implications of explored open, sustainable design considerations. Table 10 summarizes these implications in definitions of these considerations through explorations on soup making in Workshop 1.

5.2.2. Open Design Solutions for Pancake Making

5.2.2.1. Initial Solution for Pancake Making

The initial open solution for pancake making was developed by Lilli Mäkelä and Outi Mustonen. Pancake making involves the use various elements, like whiskers, mixing bowls, spatulas, etc. (Figure 67). However, the open solution they developed focusses on preparing the pancake dough, which requires mixing several ingredients (e.g. eggs, milk, flour, sugar, etc. as can be seen in the lower half of Figure 67). On the other hand, they realized the open solution they will develop can also mix other ingredients for other practices (e.g. making cakes), which may require different levels of torque to be carried out properly. They also realized mixing ingredients could be done with a fixed appliance, a handheld appliance or simply with a whisker at hand, depending on the need of power and personal preferences. Hence, they developed the "multi-purpose kitchen tool" in Figure 68.

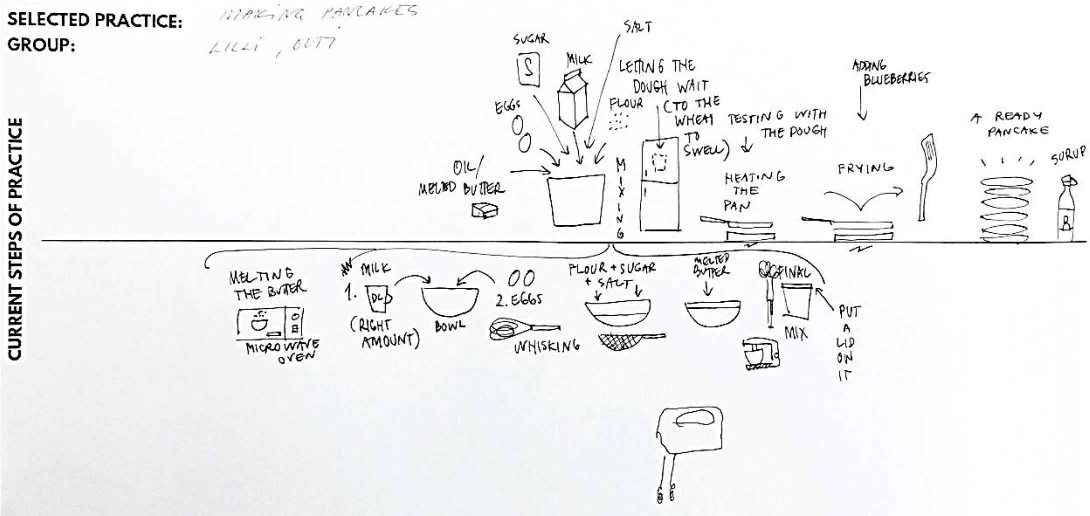

Figure 67. Practice timeline drawn by Lilli Mäkelä and Outi Mustonen to reflect on their pancake making process and context.

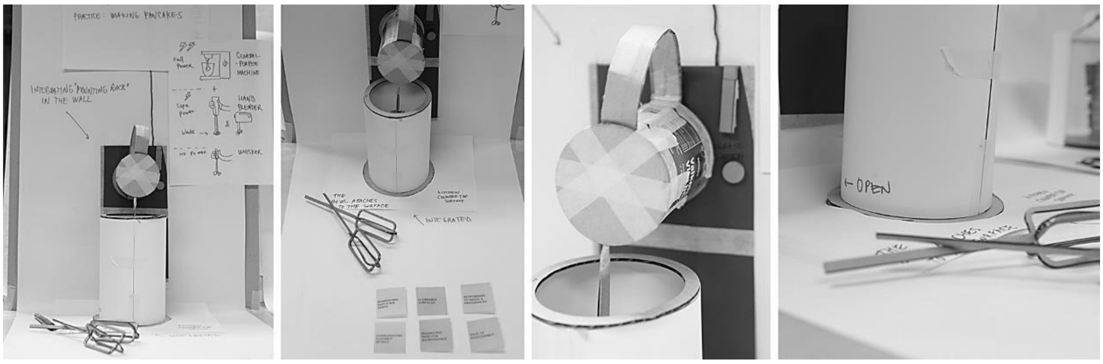

Figure 68. 3D poster of the Initial Open Solution for Pancake Making, by Lilli Mäkelä and Outi Mustonen.

Since it is hard to understand the properties of the open parts developed for this solution in the Figure 68 above, the illustration in Figure 69 is presented to show which parts were developed and how they are brought together. There is a motor housing with integrated handle that houses a motor, a gearbox and a battery, which can be used standalone or mounted to the wall through a magnetic wall mount. The wall mount also includes a status screen and an additional on/off switch to operate the machine when mounted. A whisker is temporarily attached to the motor housing, which can be replaced by other apparatus as well according to the needs and preferences of the user. A long, cylindrical container is developed to be used with the machine, which can be mounted on the kitchen counter with a container mount. The container mount can be rotated, hiding the mounting details, to provide an even surface on counter, hiding mounting details.

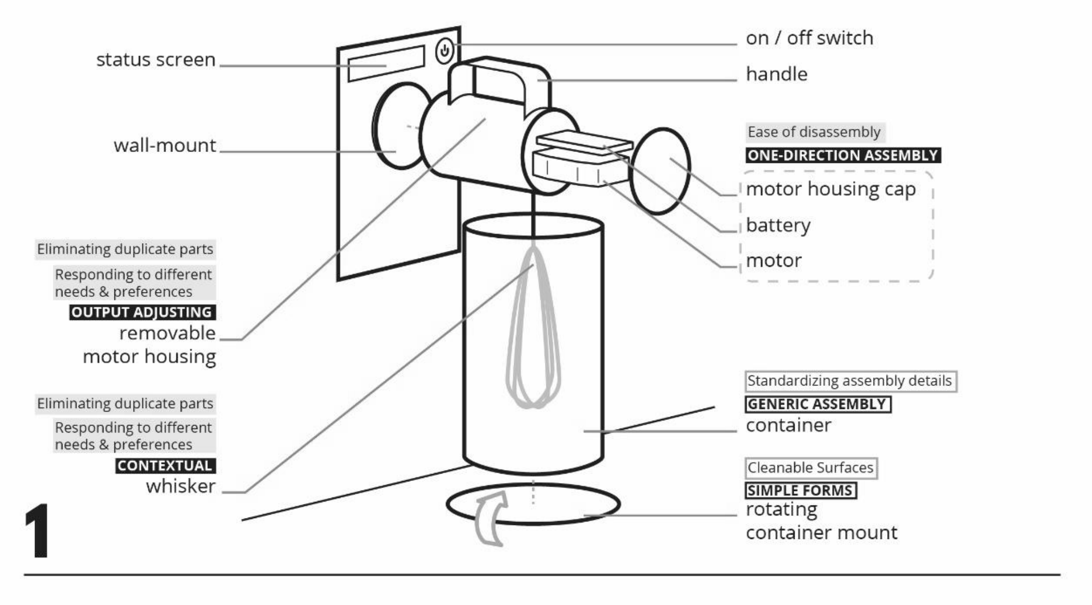

Figure 69. Illustration of the Initial Open Solution for Pancake Making, by Lilli Mäkelä and Outi Mustonen.

As an important point, this initial solution requires an additional, practical knowledge on electronics about charging the battery and running a screen when decided to be produced. Also, installing the wall-mount and the container mount requires additional skills on building and/or woodworking, and causes irreversible alterations to the kitchen environment. During their presentation, these were discussed to point out the hardships on producing and installing these parts that a user-producer or a designer-producer can face. Although the design solution is openly shared with everyone, only some people can actually produce such complex parts and there is a need for a dedicated producer.

Although this solution was developed for pancake making, the participants believed it can be used for other mixing tasks by simply using a more powerful motor and *adjust its output* through switches and use context. *Temporarily attaching* the motor housing for a fixed use and more powerful output, and removing it to be used by hand automatically adjust the output of the machine to the use context. For this regard, the whisker has a long shaft and can be removed from the motor housing to be used by itself. All these properties of the open parts *eliminate duplicate parts* by providing different ways of using the open parts in different combinations. However, for another open part, the container with mounting mechanism at the bottom, the case is the opposite as the overall design solution requires this part to function properly. Furthermore, this part cannot be replaced by any other generic container, as it doesn't have generic assembly details that can be replicated on any other container.

On the other hand, the participants mentioned how they developed the container mount to create *cleanable surfaces*. The mount can be rotated to hide away the mounting details and provide an even kitchen counter surface that can easily be wiped using a damp cloth. Although this sounds practical, it does not help with cleaning the mounting details. The ingredients that fall on the mounting detail are still hard to clean due to the intricate details of the locking mechanism.

Finally, the motor housing is developed to be opened from *one end* and the parts inside (i.e. the motor, the battery and the gearbox) can be removed from that side easily. For this purpose, they utilized *one-direction assembly* of parts – and parallel to each other – so that they can be *easily disassembled* and repaired or replaced if any one of them breaks down.

On another note, the decision to use a rechargeable battery should be questioned. Batteries are not the best source of energy, as they are bound to lose their recharging capacity and to be disposed of in time. In addition to inevitable disposal in the long run, the safe disposal of batteries is an unresolved issue with hazardous impact on environment.

5.2.2.2. 2nd Iteration for Pancake Making

This iteration was developed by Emma Berg and Maria Mercer, with a focus on the portioning of pancake dough while cooking. The idea came from their own practices, in which they would not be able to portion the dough properly and/or they would use an additional utensil (e.g. scoop) to portion it. As a result, they focused on the initially proposed container and developed it further (Figure 70).

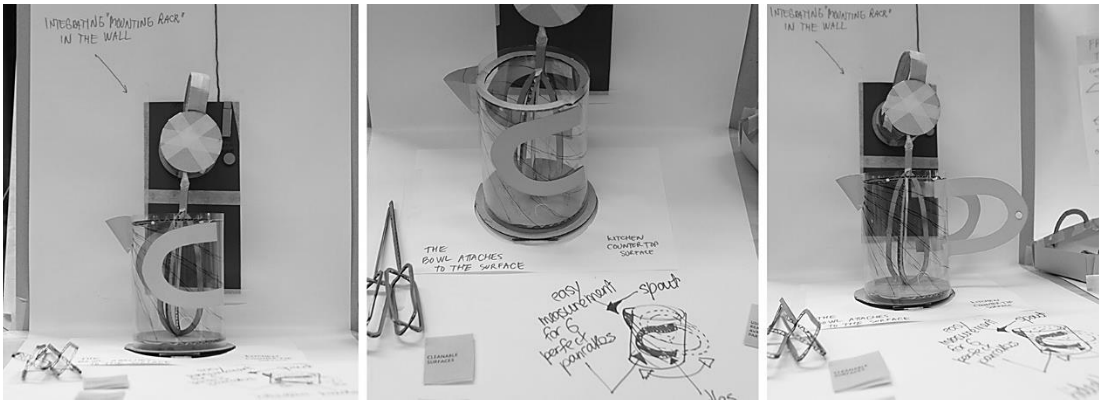

Figure 70. 3D poster of the 2nd Iteration for Pancake Making, by Emma Berg and Maria Mercer.

Figure 71 below presents the changes in open parts they made. The container's material is transparent to be able to see the ingredients and the amount of pancake dough in it. There is a spout on one side of it to easily pour the pancake dough – or any other mixture – without spilling it anywhere else. A foldable handle is added to the container, on the opposite side of the spout to be able to easily hold and control the angle of the container when pouring the dough. The handle is foldable, so that it can be stored easily and placed in the dishwasher properly. Finally, diagonal scaling lines are added – with starting point from the spout – so that they can track the amount of dough they pour.

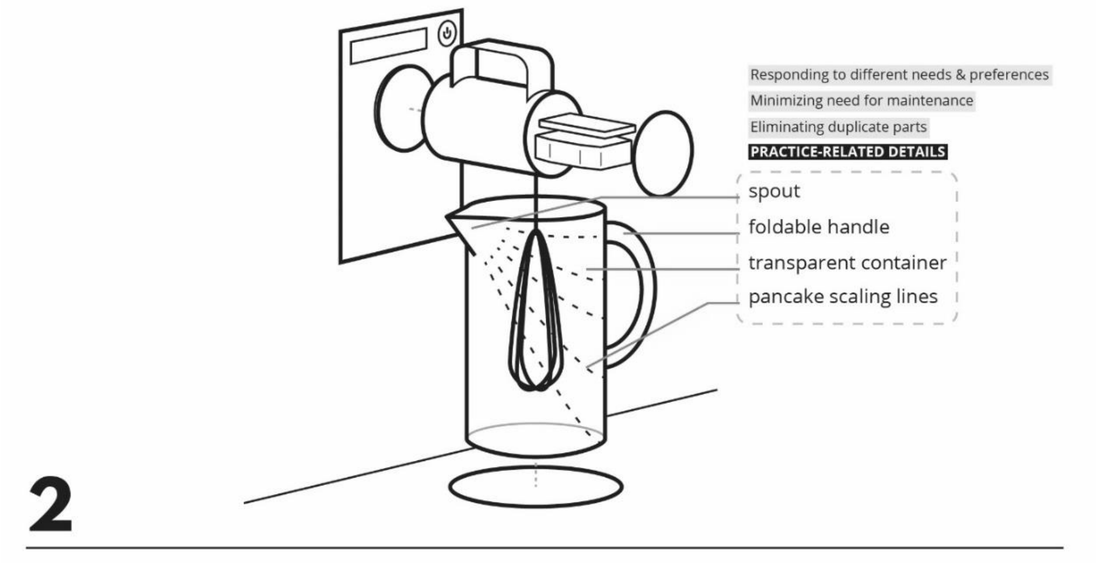

Figure 71. Illustration of the 2nd Iteration for Pancake Making, by Emma Berg and Maria Mercer.

This iteration can be considered as complementary of the initial solution, since it focuses on the next stage of the pancake making practice: cooking. Through *practice-related details* like spout, handle and measuring lines, it responds to various design considerations as well. The measuring lines and transparent material used for the bowl *eliminates the need* for additional accessories – like a measuring scoop – and prevents accidental spillage of the dough when it is transferred to and from the scoop. The participants thought that the measuring lines could also indicate different measures of scaling, like standardized milliliters, one pancake, a glass, etc. Through an integrated measuring indicator, the user can easily scale ingredients, doughs, etc. according to their needs and preferences, without using additional accessories. This also *minimizes the need for maintenance*, as there is no scoop to clean and no spillage on the counter.

5.2.2.3. 3rd Iteration for Pancake Making

Figure 72. 3D poster of the 3rd Iteration for Pancake Making, by Tianshi Shen and anonymous participant.

The final iteration for pancake making was developed by Tianshi Shen and anonymous participant. Similar to the previous iteration, this solution focuses on a completely different stage of the pancake making (i.e. serving the pancake). The difference is that; these participants did not alter any open part that was designed in the previous iteration. They also changed the context of the previous solutions and developed a serving solution for selling them (Figure 72). Realizing that such a setup for preparing pancake dough can be used for a more commercial purpose to swiftly prepare the dough over and over again throughout a workday, the participants decided to develop the solution further by completing the business model with a serving solution. The developed solution is a triangular plate made out of a washable material, which is complemented by a disposable sauce/jam portioning container made out of paper (Figure 73).

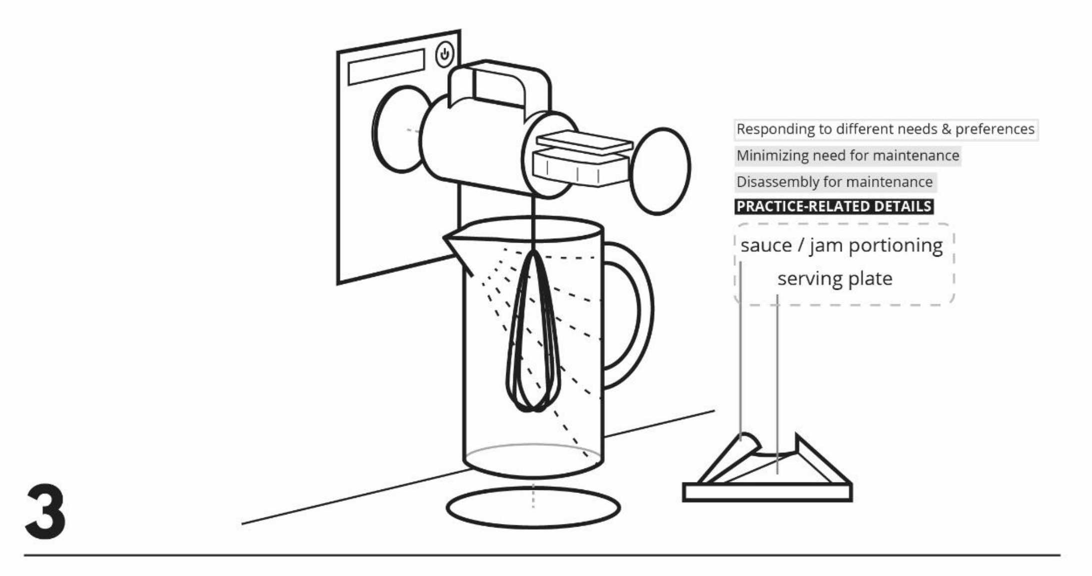

Figure 73. Illustration of the 3rd Iteration for Pancake Making, by Tianshi Shen and anonymous participant.

The participants stated that the sauce/jam portioning detail, which can come in different sizes and can be filled with any kind of pancake topping customers might want, *responds to different needs and preferences*. However, in a commercial environment like selling the pancakes, this detail is more steered towards to be a marketing element rather than to be a solution for product/part longevity and personalization. For what it's worth, it *responds to the pancake seller's marketing needs* with an open solution and helps build a profitable business. The sauce/jam portioning detail was mentioned to be made of paper, which enables the pancake seller to heat up the ingredients inside by putting it in an oven. When the customer finishes his/her pancake, the seller can remove the syrup detail and dispose of it, while s/he can clean the plates and keep them for further use. This is related to *disassembly for maintenance* and *minimizing need for maintenance* – as mentioned by the participants. Through disassembling the problematic part for syrup and jam, the maintenance of the remaining part (i.e. the plate) is minimized and the pancake seller can utilize reusable plates instead of disposable plates made of paper or plastics.

5.2.2.4. Reflections on Open Solutions for Pancake Making

The open solutions for pancake making were developed in a different way, compared to the open solutions for soup making. At every iteration, a different stage of the pancake making was questioned: Initial solution was focused on dough preparation, 2nd iteration on scaling for cooking, and 3rd iteration on serving and selling. The iterations were developed in a more additive manner (i.e. through adding new open part designs), rather than an adapting one (i.e. through changing part designs). They are more related to expanding the capabilities of the initial solution so that it can respond to differing needs and preferences of any person at every use stage (i.e. preparation, cooking, serving) and in different use contexts (i.e. domestic use and commercial use). Table 11 shows the changes in open parts among iterations and their part properties.

Table 11. Open Parts designed for pancake making.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Removable motor housing	Output Adjusting	Removable motor housing	Output Adjusting	Removable motor housing	Output Adjusting
Whisker accessory	Contextual	Whisker accessory	Contextual	Whisker accessory	Contextual
Motor housing cap	One direction assembly	Motor housing cap	One direction assembly	Motor housing cap	One direction assembly
Battery		Battery		Battery	
Motor		Motor		Motor	
Container	Generic assembly (-)	Transparent container	Practice-related details	Transparent container	Practice-related details
		Foldable Handle		Foldable Handle	
		Spout		Spout	
		Pancake Scaling Lines		Pancake Scaling Lines	
Container mount	Simple forms (-)	Container mount		Container mount	
-		-		Serving plate	Practice-related details
-		-		Sauce/Jam Portioning	

The initial solution included a removable motor housing – which regulates the motor output according to whether it is mounted or not, a whisker accessory – which can be used handheld or attached to the motor according to the context, a battery, a motor and a motor housing cap – which are assembled in one direction –, and a container with a dedicated container mount. The container is replaced with *pancake making related details* like a transparent container with pancake scaling lines, a handle and a spout for cooking. In the final iteration, a plate with a disposable syrup detail was added for serving. The additive nature of these iterations is questionable as well, due to the unchanged open parts among iterations. It is hard to tell for me that participants were content with all the open parts designed in previous stages, as some remaining parts are conflicting. For example, the 2nd iteration changes the container and adds different parts (i.e. handle, scaling lines, and spout) for the container to be used in cooking stage as well. However, those participants did not question the necessity for the container mount within their use scenario. A similar contradiction can be seen in the 3rd iteration as well, since the participants did not question the necessity of a whisker accessory that can be used both handheld and mounted to a motor, although such a handheld accessory would not be needed for such commercial purposes. An additive approach – instead of an adapting one – in open design process runs the risk of ending up with open solutions full of features and parts that a person may not necessarily need, want or use.

These changing open parts throughout the open design process provides various implications of explored open, sustainable design considerations. Table 12 summarizes these implications in definitions of these considerations through explorations on pancake making in Workshop 1.

Table 12. Design Considerations used for Pancake Making Practice in Workshop 1.

Design Consideration	**Initial definition from the analysis of existing concerns & explorations**	**Implications for explorations on pancake making in Workshop 1**
Eliminating duplicate parts	reducing the number of electrical parts (e.g. heaters, motors, switches, etc.) which are placed in different appliances for different practices.	reducing the number of electrical parts through *output adjusting* and non-electrical parts through creating *contextual* parts (e.g. whisker) or practice-related details (e.g. scaling lines).

Table 12. Design Considerations used for Pancake Making Practice in Workshop 1 (continued).

Responding to different needs & preferences	different parts that respond to the changing needs and preferences of different people should be able to be brought together, resulting in different and flexible assemblages of parts.	solutions that can respond to changing needs and preferences through *output adjusting* electrical parts, or non-electrical parts that can be used differently in different *contexts*.
Ease of disassembly	solutions that can be easily disassembled for post-use processes (i.e. maintenance, repair, upgrading)	solutions that allow the disassembly of each part separately through *one-direction assembly* for post-use processes.
Standardizing assembly details	using same or compatible assembly details for different open parts to enable different part assemblages	using *generic assembly* details so that wide-ranging open parts can be brought together to enable different part assemblages.
Cleanable surfaces	surfaces void of unreachable details and able to withstand abrasion, to ease their maintenance	*simple forms* void of unreachable details to ease their maintenance.
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and kitchen environment	*practice-related details* that reduce the number of parts used to carry out a practice.
Disassembly for maintenance	solutions enabling the disassembly of parts for maintenance/cleaning. For some parts, they need to be disassembled so that surfaces that come into contact with ingredients can be reached. For others, they are positioned close to the electrical parts and they should be separated to prevent water damage.	*practice-related details* (e.g. sauce/jam portioning) disassembled for ease of maintenance.

5.2.3. Open Design Solutions for Salad Making

5.2.3.1. Initial Solution for Salad Making

The initial solution for salad making was developed by Emma and Maria, which was focused on washing, peeling and chopping the ingredients (e.g. tomatoes, carrots, etc.). They mentioned that washing these ingredients properly is the most important task of preparing a salad, as they might have dirt and other various chemicals that may affect their health. On the other hand, peeling ingredients was thought to be the most demanding task of preparing a salad, which also results in lots of food waste. Hence, they developed the open design solution for washing and peeling in Figure 74. The design solution includes a motor and motor housing, a container lid, a transparent container, metal peeling brushes and a plug (Figure 75). Since they opted for a motorized washer and peeler, they also suggested that the peeling brushes could be replaced with blades to chop the ingredients as well.

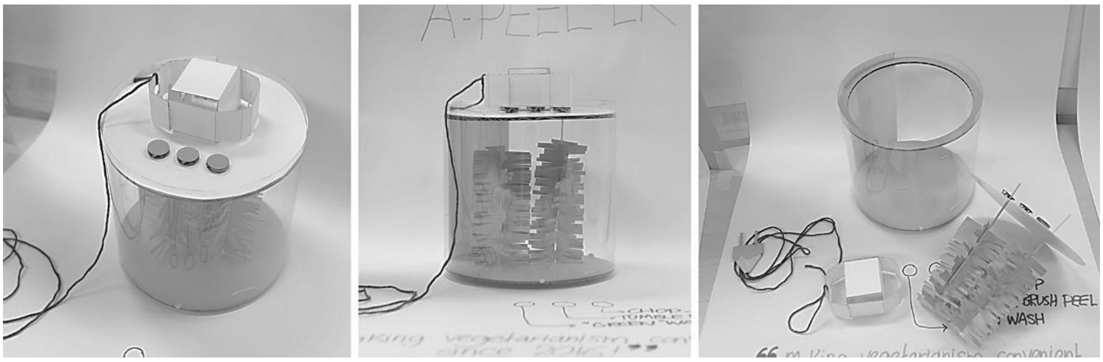

Figure 74. 3D poster of the Initial Open Solution for Salad Making, by Emma Berg and Maria Mercer.

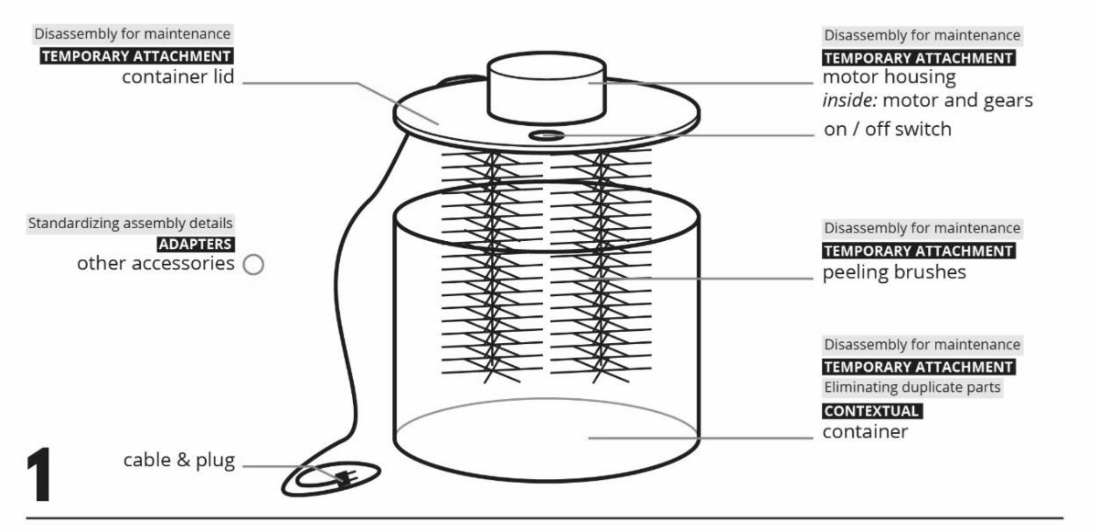

Figure 75. Illustration of the Initial Open Solution for Salad Making, by Emma Berg and Maria Mercer.

The participants thought that the container could be used throughout the salad making and eating process. It is designed to be produced out of clear glass, which makes it easier to clean throughout the process. Hence, the idea was to (1) peel the ingredients, (2) rinse it under a tap, (3) replace the peeling brushes with blades, (4) chop the ingredients, (5) remove the motor housing, lid and accessories, and (6) serve it with the container. They put emphasis on the material selection to enable the use of the container in *different contexts* (i.e. container to wash, to peel, to chop and to serve). That is also the reason why they tried to keep the form of the container *simple* and void of complex locking mechanisms that would make it hard to rinse the container. Consequently, this *eliminates* the need for several containers throughout salad making and *minimizes need for maintenance*. The container lid's *temporary attachment* is also useful for the life span of the electric motor, as it can be *disassembled* from the container during cleaning. Similarly, the accessories are also *temporarily attached*, because they need to be thoroughly cleaned, which would be hard when they are attached to the electric motor.

The participants mentioned that by using different accessories to replace the peeling brushes with other accessories (e.g. strainer, chopping blades of different sizes, graters, etc.), this solution can *respond to* different preferences on ingredients and their size. They also mentioned that 3D-printed *adapters* could be designed and shared online to enable the use of other generic accessories with the motor housing of this solution. This is an interesting approach to *standardizing assembly details* for kitchen appliances and accessories, which can potentially *eliminate* the need for several of the same accessory with different assembly details in the kitchen environment.

5.2.3.2. 2nd Iteration for Salad Making

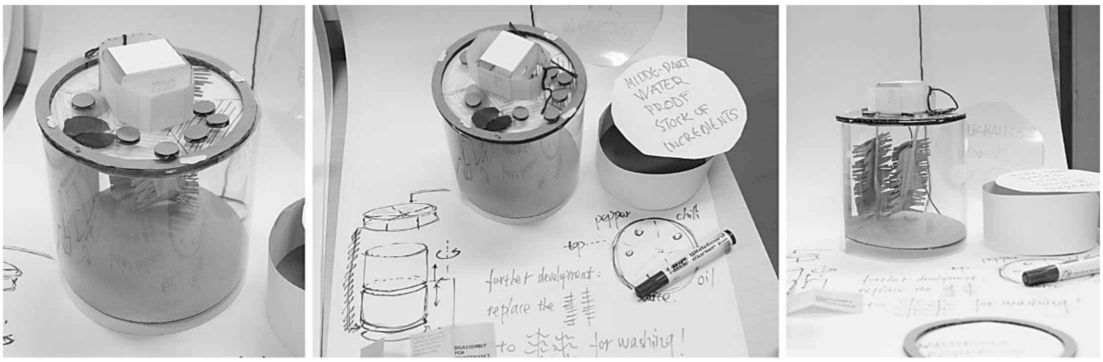

Figure 76. 3D poster of the 2nd Iteration for Salad Making, by Tianshi Shen and anonymous participant.

This iteration was developed by Tianshi Shen and anonymous participant. They wanted to create a way to use the motor for mixing the ingredients along with oil and other seasoning, and serving it to individuals, hence they developed the solution in

Figure 76. As can be seen in Figure 77, the container lid contains small seasoning containers with press-buttons, through which different seasoning and sauces can be added inside the bowl/container. Furthermore, the container can be divided horizontally into two bowls, with the use of a divider.

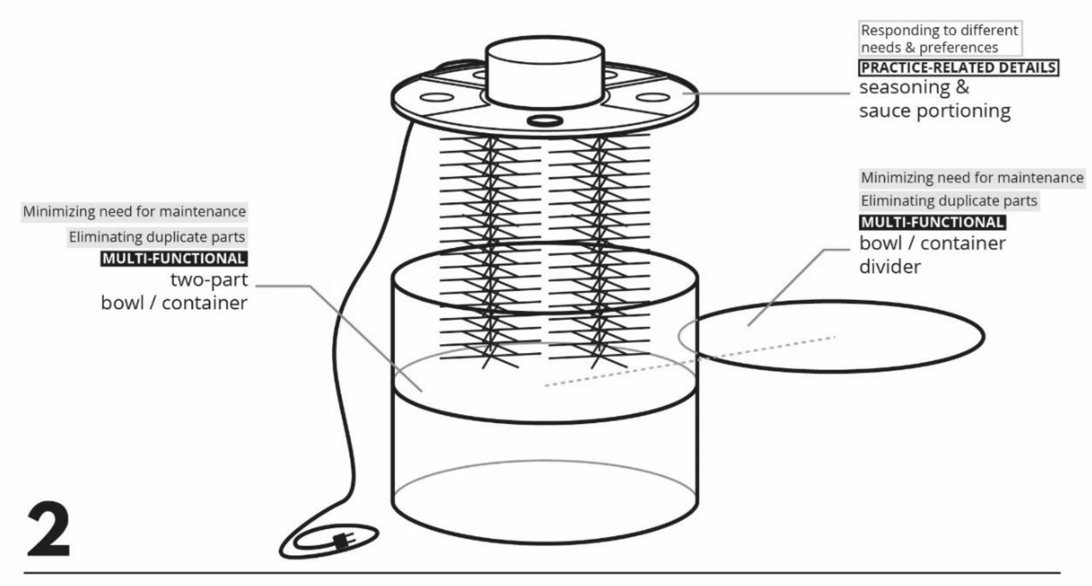

Figure 77. Illustration of the 2nd Iteration for Salad Making, by Tianshi Shen and anonymous participant.

The participants thought that the seasoning portioning detail of the container lid – as a *practice-related detail* – would *respond to* different salad eating preferences. With such a design detail, the seasonings and sauce can be portioned easily and quickly, and the remaining seasoning can be stored inside the bowl/container lid for later use. However, this is a design detail with negative implications on maintenance. Considering the nature of seasoning and sauce, they may be sticky and hard-to-clean. Located close to the motor housing, to which the portioning detail is permanently attached, it would be hard to clean this part as it cannot be put in the dishwasher or can be thoroughly cleaned in sink. Furthermore, it is a seasoning container in addition to existing ones in the kitchen context, which can only be used with this design solution and nothing else. This also brings forth a question on how to design *practice-related details* for kitchen practices. These details should be designed, reflected upon and assessed in accordance with the sustainable design considerations, in this case *minimizing need for maintenance* and *disassembly for maintenance*.

The second difference in this iteration is the container part, which can be divided into two bowls and can be used for eating the salad. They mentioned that this *multi-functional* property of the open part *eliminates* the use of additional bowls by portioning the prepared salad. Consequently, no other dish is used throughout this process, *minimizing need for maintenance*. However, the participants did not suggest a *temporary attachment* solution for the divider and the upper part of the container. Although it seems like a solution with potential benefits on maintenance, technical problems about leakage may surface when it comes down to producing these parts.

5.2.3.3. 3rd Iteration for Salad Making

The final iteration for salad making was developed by Lilli Mäkelä and Outi Mustonen. The participants wanted to separate and utilize the water used for washing the ingredients and the biological waste from the peeling process, through collecting them in a separable waste container (Figure 78). In this iteration, the participants did not focus on the serving, but rather on the maintenance aspect of the solution.

Figure 78. 3D poster of the 3rd Iteration for Salad Making, by Lilli Mäkelä and Outi Mustonen.

The different parts in this iteration can be seen in Figure 79. The container is replaced by a bottomless container, a strainer bottom and a waste collector. On the other hand, the participants decided that they will need different speeds for washing and chopping different ingredients (e.g. slow for washing lettuces, fast for peeling potatoes), hence they added a speed-adjusting knob next to the on/off switch.

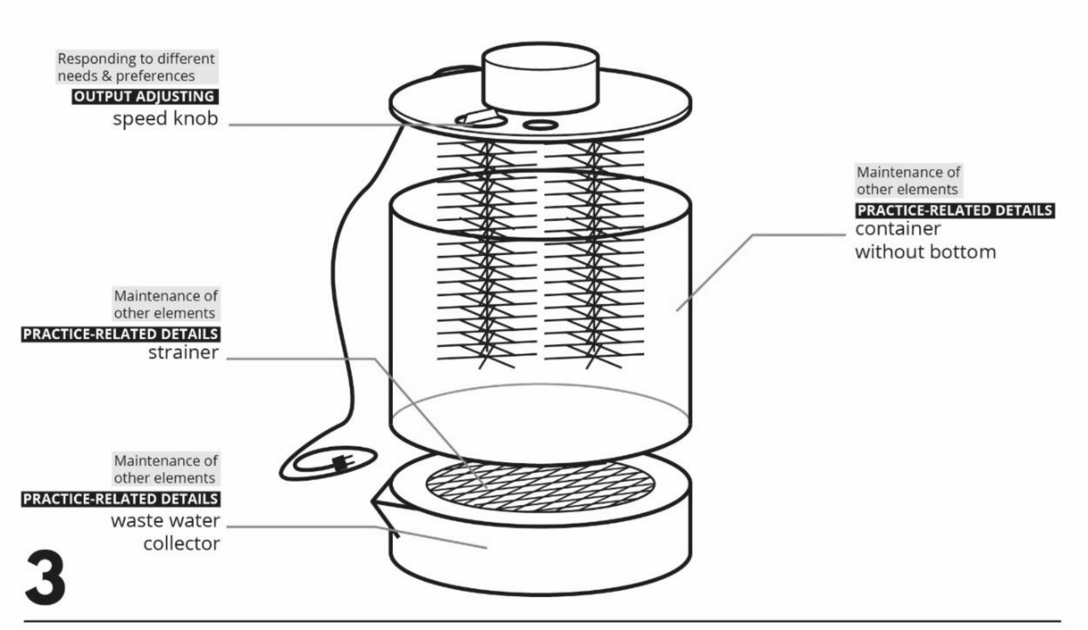

Figure 79. Illustration of the 3rd Iteration for Salad Making, by Lilli Mäkelä and Outi Mustonen.

The participants realized that throughout the salad making process lots of organic waste turns up, which needs to be either separately thrown away or which can be used for other purposes (e.g. watering the plants). It should be noted here that waste separation is necessary in Finland, which is also supported by the sale of organic waste bags sold in the supermarkets and organic trashcans located in every neighborhood. Through the strainer and waste water collector bottom, the participants thought that they could collect dirt and waste of the processes and prevent any clogging of the kitchen sink. These design details are *related specifically to* salad making practice and helps *maintain* the kitchen sink.

Another design detail the participants introduced was the speed-adjusting knob. They wanted the option of *output adjustment* for this solution, so that it can *respond to* their needs and preferences for different salad ingredients. For example, they want the motor to rotate slowly when they are washing sensitive ingredients like lettuces, so that they are not harmed. On the other hand, they need a faster output when they want to peel hard ingredients like carrots or potatoes.

5.2.3.4. Reflections on Open Solutions for Salad Making

The iterations developed for salad making present the potential of open design through branched out development of solutions. Instead of adapting the solution by changing different open parts through collective knowledge (i.e. like in the iterations of soup making) or continually adding parts to respond to practice in a more holistic way (i.e. like in the iterations of pancake making), the initial solution was altered in completely different ways in both the 2nd and the 3rd iteration. The 2nd iteration focused more on serving, through seasoning/sauce portioning detail and two-part container/bowls, while the 3rd iteration scratched all these changes and changed the container in the initial solution to collect waste water. The changing open parts among these iterations can be seen in Table 13.

Table 13. Open Parts designed for salad making.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Motor housing	-	Motor housing	-	Motor housing	-
Cable & Plug	-	Cable & Plug	-	Cable & Plug	-
On/off switch	-	On/off switch	-	On/off switch	-
Peeling brushes & other accessories	Temporary attachment, Adapters	Peeling brushes & other accessories	Temporary attachment, Adapters	Peeling brushes & other accessories	Temporary attachment, Adapters
Container Lid	Temporary attachment	Container Lid w/ seasoning portioning	Temporary attachment, Practice-related details	Container Lid	Temporary attachment
Container	Temporary Attachment, Contextual	Two-part Container/ bowls	Temporary Attachment, Multi-functional	Bottomless Container	Practice-related details
		Container Divider	Temporary Attachment, Multi-functional	-	
				Strainer	Practice-related details
				Waste Water Collector	Practice-related details
				Speed Adjustment Knob	Output adjusting

The initial solution consists of a motor and a gearbox inside a motor housing, which is attached to container lid with an on/off switch and cable & plug, a pair of temporarily attached peeling brushes and other not-detailed accessories for washing and chopping ingredients which may be generic tools that are attached using adapters, and a transparent, temporarily attached container which can also be used for serving. The functional aspects of these accessories may be questionable, as they are suggesting an innovation, the effectiveness of which cannot be tested until those parts are produced out of the suggested materials. From here on out, the iterations branch out towards different directions. The 2nd iteration focuses on serving the salad, and replaces the container with two-part, separable, multi-functional container and a temporarily attached divider. It also adds practice-related details – seasoning/sauce portioning details – to finalize the salad making inside the same container. The 3rd iteration, however, builds upon the initial solution as well, focusing on the waste disposal, replacing the container with other practice-related details: a bottomless container, along with a strainer and a waste water collector. It also adds a speed knob to adjust the power output of the motor.

Table 14. Design Considerations used for Salad Making Practice in Workshop 1.

Design Consideration	**Initial definition from the analysis of existing concerns & explorations**	**Implications for explorations on salad making in Workshop 1**
Eliminating duplicate parts	reducing the number of electrical parts (e.g. heaters, motors, switches, etc.) which are placed in different appliances for different practices.	reducing the number of non-electrical parts through utilizing same parts in different *contexts* or designing *multifunctional* parts.
Disassembly for maintenance	solutions enabling the disassembly of parts for maintenance/cleaning. For some parts, they need to be disassembled so that surfaces that come into contact with ingredients can be reached. For others, they are positioned close to the electrical parts and they should be separated to prevent water damage.	enabling the maintenance of parts (e.g. container, brushes) and separating electrical and non-electrical parts to prevent water damage to electrical parts (e.g. motor) by bringing them together with *temporary attachments.*
Standardizing assembly details	using same or compatible assembly details for different open parts to enable different part assemblages	using *adapter* parts so that different parts can be integrated into the open solution.
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and kitchen environment	*multi-functional* parts can reduce the number of parts to be maintained.

Table 14. Design Considerations used for Salad Making Practice in Workshop 1 (continued).

Responding to different needs & preferences	different parts that respond to the changing needs and preferences of different people should be able to be brought together, resulting in different and flexible assemblages of parts.	solutions that can respond to changing needs and preferences through *output adjusting* electrical parts, or non-electrical parts with *practice-related details* (e.g. seasoning)
Maintenance of other elements	-	*practice-related* solutions (e.g. collecting dirt that can clog the sink) to maintain other elements (e.g. sink)

These changing open parts throughout the open design process provides various implications of explored open, sustainable design considerations. Table 14 summarizes these implications in definitions of these considerations through explorations on salad making in Workshop 1.

5.2.4. Group Discussion in Workshop 1

As mentioned in *Section 3.3. Design workshops*, a group discussion was conducted at the end of the workshop to gather insights of participants about their design process, sharing open design solutions and the relation between sustainability and open design. The analysis of the group discussion revealed the limitations and opportunities for the next workshop, as well as informed reflections on open, sustainable design process.

5.2.4.1. Designing and Generative Tools

Initially, idea-generation and the utilization of generative tools (i.e. practice timelines, generative design toolkit, and sustainability consideration cards) were discussed, opportunities of which are mentioned as follows:

- The practice timelines were found useful in two aspects: to recall their own practices and to share the way they carry out those practices with other group members. Through recalling their own practices, and discussing the problems they face while carrying out those practices, the participants were able to generate ideas specific for their own practices.

- Analyzing their own practices through practice timelines, the participants used sustainability consideration cards to reflect on their practices and to develop alternative design solutions accordingly. In addition to inform the idea-generation, the cards were also used to assess the developed ideas. Overall, cards were useful tools to develop ideas that respond to sustainability concerns of the study.
- The generative design toolkit (i.e. representational cardboard parts, guides to help them quickly create different forms in different sizes, and readily available parts) helped the participants to perceive the dimensions and shapes of various parts and take these into account while designing open parts. It also helped them to quickly create mock-ups to test and finalize their ideas. The contents of the generative design toolkit were also found easy to understand and utilize.

On the other hand, these tools also presented some limitations with regards to their utilization and timing:

- The second half of the practice timelines were not filled by the participants due to two reasons. The time allocated for each iteration was insufficient to also formulate and fill in the new practice timeline, as the participants were focused on building their mock-ups. On the other hand, they also thought that they were already going to share the new practice during the presentations. Hence, they left the second half of the practice timelines blank.
- It took time to understand what each sustainability consideration card means and how they can be reflected on open design solutions. They mentioned the use of visual cues and design details on these cards could have helped them to understand the implications of the considerations more quickly. This was also observable throughout the workshops, as participants frequently asked questions about considerations.

5.2.4.2. Sharing Open Design Solutions, 3D posters and Presentations

During the workshop, open design solutions were developed with different drivers in each iteration. The presentations made after every iteration and 3D posters as sharing mediums were mentioned as easing the sharing process among participants. Being able organize informative posters with sustainability consideration cards was mentioned as practical. On the other hand, relating open parts designs and their features with the considerations they used helped both with making presentations and, in return, easily understanding the open solutions they were going to adopt for the next iteration.

As a limitation of using the sustainability consideration cards during these presentations, the participants mentioned that they made connections between some considerations and open part designs while they were presenting their solutions. Some participants mentioned that these after-design connections were not reflected upon while they were designing and building mock-ups, but they have come to realize the potentials of their solutions after designing. Considering this from a methodological perspective, the presentations acted as both reporting their reflection-in-action and a tool for reflection-on-action through raising awareness on these considerations and the applicability and relevancy of the design solutions.

One of the groups also mentioned that, through listening to the presentations, they were able to develop the third iteration of salad making directly from the initial solution rather than continuing from the second iteration. Through the presentation made for the initial solution on salad making, the participants were informed about it and decided to develop the 3rd iteration from the initial solution, as the alterations in the 2nd iteration did not respond to their needs and preferences. This is an important remark which brings forward how open design solutions can be developed in a branched manner, as well as in a linear fashion.

5.2.4.3. Sustainability Concerns and Open Design Process

The insights on the implications of open design for sustainability were conflicting in nature, as the participants pointed out two opportunities and one major limitation. These insights are presented below.

Upon experiencing an emulation of open design process first hand, all the participants talked about the iterative nature of the open design process and its usefulness to adapt any open solution to different local and/or individual needs and preferences through the process. They mentioned the ability of changing and adapting an existing solution to include only the parts and features one needs or prefers and leaving the parts one does not need or want is the most prominent opportunity of open design process. Hence, they suggested, design solutions can be developed further with every iteration or can be expanded with every additional feature or open part, to respond to other needs and preferences the previous person who designed the solution may not be able to foresee. These comments are in parallel with the personalization aspect of this study and they are valuable as the participants mentioned these after experiencing the process first hand and verified it.

One of the participants mentioned the reachability of digital fabrication technologies (e.g. 3D printers, laser cutters, etc.) as an opportunity for the above mentioned iterative potential of open design on personalization, as well as an opportunity to use and reuse parts that are not specifically designed with standardized assembly details. Adapters of sorts can be designed and produced to include closed or unique parts in different open solutions. This potential is pointed out to be important for part longevity, through reusing existing parts that were not openly designed.

On the other hand, the intentions of future contributors of open design process were referred as the most decisive for the utilization of sustainability considerations. The participants all agreed upon that, even if the contributors are presented with sustainability considerations, they might not reflect upon them during the open design process to elongate lifespans of open solutions. This was a more general critique towards adoption of sustainable practices not only for open design process but also for current consumption practices. Contributors' awareness on and understanding of sustainability definitely affects the open design process and its outcomes.

5.3. Conclusions for Workshop 1: Iterating Open Solutions for Same Practice

The analysis of the workshop outcomes revealed open part properties that can respond to sustainability considerations presented to the participants. It also revealed diverse ways open design solutions can be iterated, with different implications for the sustainability concerns of the study (i.e. product/part longevity, personalization, maintenance, repair and part reuse). The following sections present how these results contribute to the exploration of open design for sustainability.

5.3.1. Open, Sustainable Design Considerations and Open Part Properties Emerged from Workshop 1

The design explorations developed by the participants of Workshop 1 revealed how open design process can respond to sustainability concerns of this PhD study, along with sustainable design considerations directly or indirectly related to these concerns and open part properties that can accommodate these considerations. The workshop outcomes discussed in previous sections are fruitful explorations that show how these sustainable design considerations manifest tangible outcomes and how these open part properties can be used for kitchen practices.

Table 15 below presents all the sustainable design considerations used during the workshop and all the open part properties emerged from these explorations. The light grey design considerations (i.e. individual skills for production, local skills for production, using readily-available parts, feedback on breakdown reasons, feedback on maintenance need) are the ones that were not reflected upon by any participants in this workshop. On the other hand, two new open, sustainable design considerations emerged during this workshop: *durability of parts* and *maintenance of other elements.*

The use of *generic assembly details* or *adapters* respond to *standardizing assembly details* consideration and enable the use of different open parts in different open solutions for different purposes. This is also related to *contextual* parts. *Contextual* parts are the parts that can be used for different purposes throughout kitchen practices. The examples of these parts can be a container for washing ingredients and later for serving the prepared food, or a whisker that can be used handheld or attached to a motor. These parts can be used to *eliminate duplicate parts*, or they can be used differently (e.g. handheld or attached to a motor) to *respond to different needs and preferences*. Similarly, *output adjusting* electrical parts (e.g. motor), *practice-related details* (e.g. scaling lines) and *multi-functional* forms (e.g. truncated pan/pot, oven tray/cutting board) were developed to e*liminate duplicate parts* and to *respond to different needs and preferences* considerations. *Transforming* parts (e.g. crank and blades that can be attached to lids) were developed to be optionally included parts that *respond to different needs*.

Some practices can affect other elements in kitchen (e.g. sink) and their functions (e.g. clogging), and they may require solutions specifically for that practice. For example, washing the ingredients of salad is such a practice, which needs to consider the clogging of the sink and its maintenance. Hence, *practice-related details* may be necessary to ease the *maintenance of other elements*. As for the maintenance of open design solution, *simple forms* and *temporary attachment* details with no intricate details that are hard to clean can be developed for *cleanable surfaces*.

Table 15. Design Considerations responded in Workshop 1 among all design considerations related to Open Part Properties used.

	One-direction assembly	Generic assembly details	Adapters	Contextual	Output Adjusting	Transforming	Practice-related details	Conditional	Multi-functional	Simple Forms	Temporary attachment
Standardizing assembly details		●	●	●							
Cleanable surfaces										●	●
Minimizing need for maintenance									●		
Feedback on maintenance need											
Feedback on breakdown reasons											
Ease of disassembly	●										
Responding to needs & preferences				●	●	●	●		●		
Using readily-available parts											
Eliminating duplicate parts				●	●		●		●		
Disassembly for maintenance											●
Individual skills for production											
Local skills for production											
Durability of parts								●			
Maintenance of other elements							●				

Temporary attachments need to be taken into account during the assembly of parts to ensure *disassembly for maintenance* as well. Open part designs enabling *one-direction assembly* is an important property for parts, as it directly relates to *ease of disassembly* consideration for post-use processes (i.e. repair, upgrading, reuse). Finally, *conditional* parts (e.g. double handle for bigger pot) need to be identified and taken into consideration to ensure *durability of parts*.

5.3.2. Flowchart of Sustainability Considerations and Part Properties for Open, Sustainable Design Process

The above-mentioned design considerations affect different stages in an open design process, and they should be considered accordingly. However, to create a flowchart of open design process emerged in Workshop 1, the way the iterations changed during the workshop needs to be understood. The stories of iterations for each kitchen practice reveals different strategies of adopting open design solutions (Figure 80). These strategies vary according to the nature of the changes made in each iteration (i.e. adaptive and additive) and the continuity of the changes (i.e. continual and branched). Initially, these strategies will be briefly explained and their implications on sustainability will be discussed in this section.

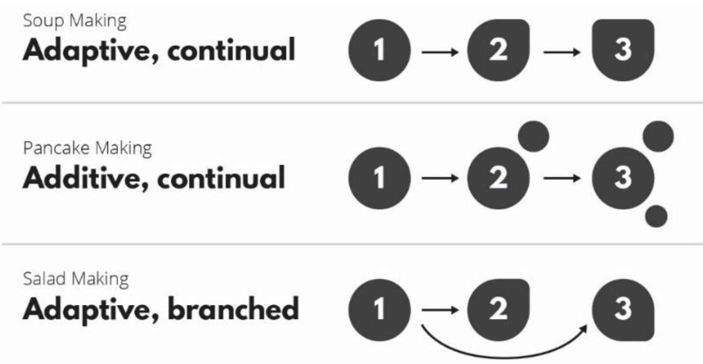

Figure 80. Different strategies of adopting open design solutions emerged from Workshop 1.

An *adaptive* process, as visible in soup making and salad making iterations, includes changing of open parts of the initial solutions to better respond to people's needs and preferences for those solutions. An *adaptive* process enables the alteration of the initial solution to respond to specific personalized choices of different people in each iteration, hence they would include only the preferred, needed parts and features for each individual. This is important to prevent the inclusion of unused parts in design solutions, as well as development of initially designed parts to better respond the sustainability considerations.

An *additive* process, as in the pancake making iterations, can respond to different needs in different stages of a practice, expanding the solution for *more* needs and preferences. In this process, the initial idea is adopted without any alterations and new parts and features are added. Although this is also important to expand the solution ground to respond to different stages of a practice, it fails to reflect upon the open parts and features of the initial solution, which people may or may not need for their own practice. In addition, since the initially designed parts are accepted as they are, no further considerations on the initial open parts are tried.

The continuity of the iterations is also important to understand the development of open design iterations and their implications for the concerns of the study. In soup making and pancake making, the iterations are continual as each group develops the previous idea further according to their needs, preferences and sustainable design considerations. However, in salad making, the 2nd group develops the initial solution and after that 3rd group scratches all the changes in 2nd iteration and develops another iteration based on the initial solution. This branched process is also important for personalization simply because the 3rd group decided the changes in the 2nd iteration are not suitable for their own salad making practice.

The above-mentioned strategies reveal that there is no one right way of adopting and adapting initially developed open design solutions. Although a continual process may develop the open solutions to better respond to the sustainable design considerations with every iteration, a branched process may reduce the number of unused parts in every solution. An additive approach may expand the solution ground to include different stages and aspects of a kitchen practice, while on the other hand an adaptive approach may refine the initial solution to better respond to sustainability concerns of the study. Consequently, the implications of open design do not only reside in the ability to select and bring together various initially designed parts in different assemblages, it also resides in the expansion of the solution ground through refining existing open parts and proposing new parts.

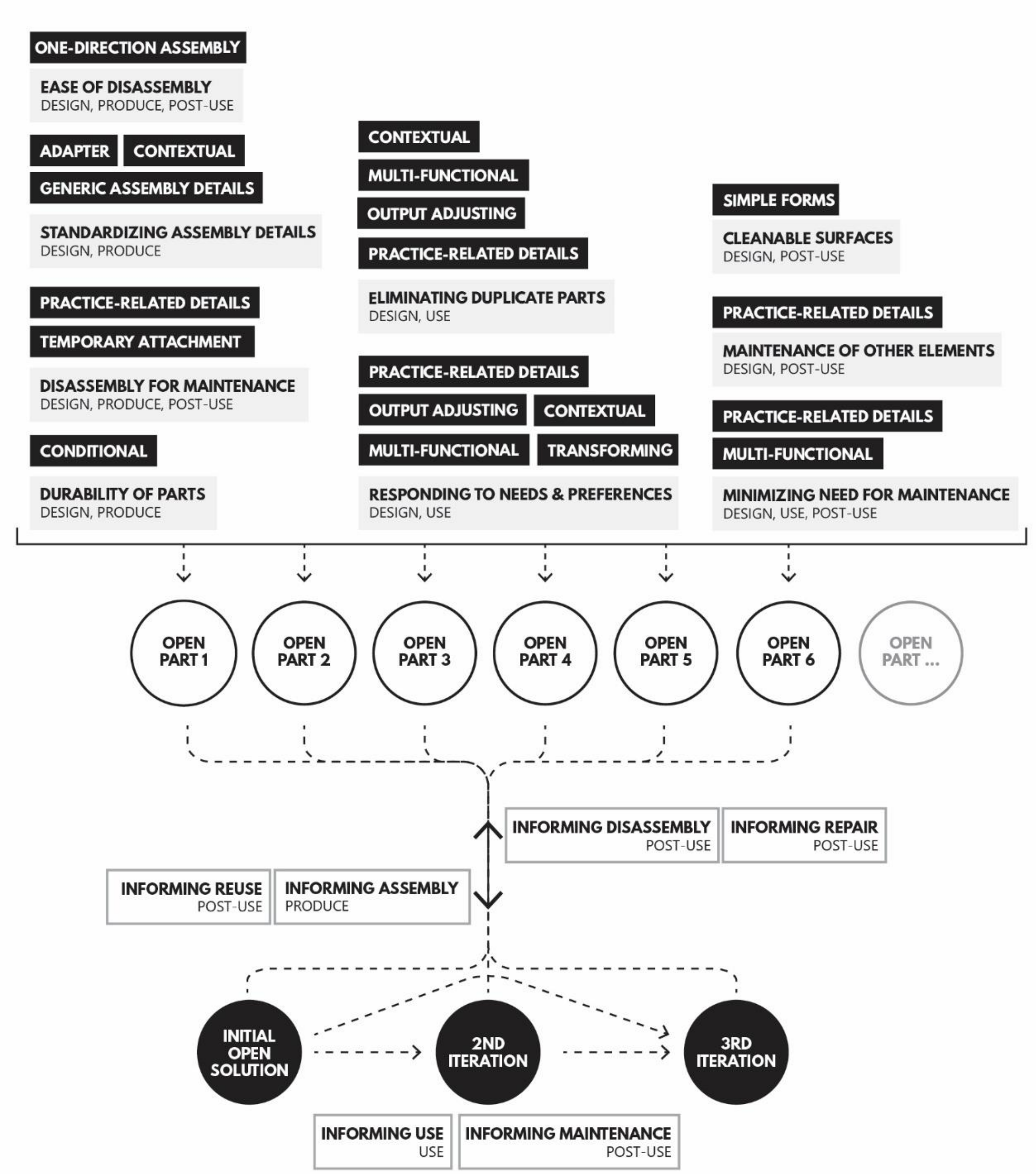

Figure 81. Open Design Process emerged through the analysis of Workshop 1.

As a result of the workshop, the flowcharts for open, sustainable design processes in *Section 4.3. Understanding Open, Sustainable Design Processes for Kitchen Practices* are advanced further to include these strategies – or the differences in possible processes – and adopted sustainable design considerations (gray rectangles) and responding open part properties (black rectangles) in Figure 81. The process flowcharts in *Section 4.3* were separated into different sustainability concerns, and they were derived from the few existing explorations. The flowchart in Figure 81 was depicted upon exploring the iterations, how they change and how they respond to sustainability considerations. It also shows which design considerations affect different stages of open part designs, their production, use and post-use.

The upper side of Figure 81 presents design considerations and open part properties together, as there is not one specific consideration or property affecting one specific stage of the process. The part properties can affect different considerations in different open part designs, hence they need to be taken into account according to the practice at hand. Upon the design and production of open parts – or decision to reuse an existing part – they are assembled together to end up with an open solution (i.e. *informing reuse* and *informing assembly*). The use and maintenance of open solutions change greatly according to the solution at hand and the practice it is used for (i.e. *informing use* and *informing maintenance*). If any part is broken, it is disassembled and repaired (i.e. *informing disassembly* and *informing repair*). If the solution is no longer useful and need alterations, it is disassembled into open parts (i.e. *informing disassembly*), some of those parts are reused in the next iteration (i.e. *informing reuse*) along with new open parts that were designed according to design considerations on top.

5.3.3. Changes for the Next Workshop

The flowchart developed according to the strategies of adopting open design solutions in Figure 81, while showing important aspects of how solutions for same practice can be iterated and open parts can be reused for the same practice, does not represent how open parts can be reused for practices other than their intended ones. This is due to the structure of the workshop, as the participants were only asked to iterate solutions for the same practice. However, another strength of open design lies within its ability to reuse open parts for different practices. Hence, the structure of the next workshop is constructed to explore this aspect of open design and its implications for part longevity, personalization and reuse.

During the group discussion, the inability to fill out the second half of the practice timelines and the problems in understanding sustainability consideration cards were raised. Throughout the workshop, I was able observe these as well. The second half of the practice timelines were not filled out, as the participants were occupied with preparing 3D posters. Also, while they were presenting their open solutions they explained in detail how they formulated their new practice along with their open design solutions. In addition, I observed that each group used the practice timelines differently – without a common structure. This lack of structure on these timelines made them harder to analyze. As for the sustainability consideration cards, I was asked different questions about their meanings throughout the workshop. Although I answered them properly, while avoiding any restrictive comments, I realized these cards need to be redesigned for the next workshop via providing more tangible and explanatory examples.

CHAPTER 6

WORKSHOP 2: ITERATING OPEN SOLUTIONS FOR DIFFERENT PRACTICES

Following upon the Workshop 1, I was able to pinpoint the shortcomings of the outcomes and the process. As a potential of open design, open parts can be utilized in different contexts for different purposes in addition to iterating them for the same practices. The structure of the previous workshop was about understanding how same practice is iterated by different people. With Workshop 2, I wanted to understand how people can transform a solution for one practice to a solution for another practice, by reusing open parts to suit their needs and preferences. Consequently, Workshop 2 – details of which will be explained later – was conducted on September 22th, 2016, in METU Department of Industrial Design, Ankara, Turkey, as a part of the 2nd National Design Research Conference *[2. Ulusal Tasarım Araştırmaları Konferansı (UTAK)]*.

This workshop was also open to all without any limitations on who can participate according to their professional and educational background, however due to the topic and the intended audience of the conference, only industrial design students and professionals who were interested in open design and who wanted to explore its potentials for sustainability attended the workshop. There were 12 participants, all of which agreed on sharing their personal information so that I can use their names under their work and record the ownership of the ideas developed during the workshop [see *Appendix D – Consent Form for the Participants of the Workshop 2 (in Turkish)*].

An important difference of Workshop 2 was the number of participants. As there were 12 participants, I realized one facilitator would not have been enough to facilitate this workshop and document the outcomes. Hence, Workshop 2 was conducted with two additional facilitators. My colleagues Dilruba Oğur and Senem Turhan kindly accepted my request for help in this workshop. Prior to the workshop, we had two meetings. During the initial meeting, I shared the topic of my PhD study, its methodology, the role and structure of Workshop 1, the generative tools used, and its outcomes. In the second meeting, I presented the generative tools developed for Workshop 2 (see *Section 6.1. The Structure of Workshop 2 and Generative Tools Used*) and we discussed the facilitation of Workshop 2 and the documentation of its outcomes.

Similar to the previous workshop, an introductory presentation was given to communicate what open, sustainable design means – as presented throughout this study. Through the presentation, the participants were informed about the sustainability concerns of the study (i.e. product/part longevity, personalization, maintenance, repair and part reuse) and potential scenarios in open design process (i.e. creating, sharing, implementing, and adapting). Following upon the general introduction into the topics of the workshop, the theme (i.e. kitchen practices shaped around small kitchen appliances, e.g. pancake making, grilling sandwiches, etc.) was introduced along with practice-based design approach and how to proceed with generating ideas through contextual scenarios. Finally, the tools developed for the workshops were introduced, the changes in which are explained in the next section.

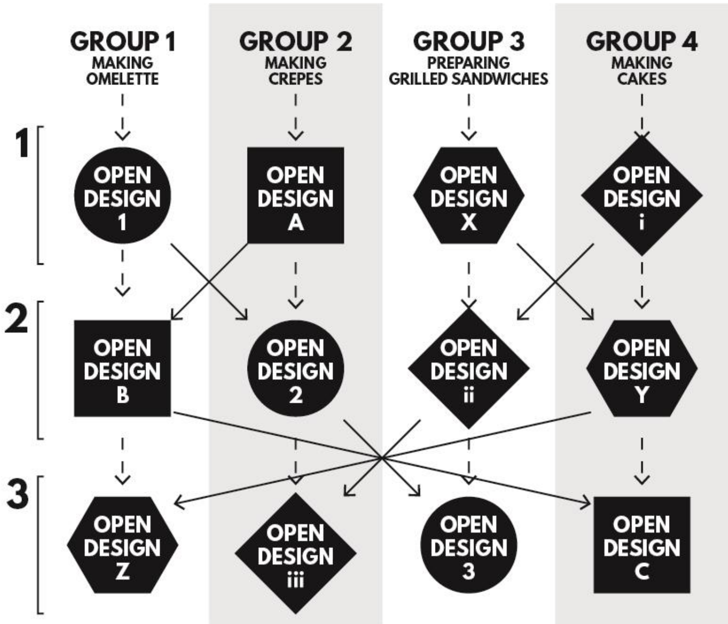

Figure 82. The structure of Workshop 2: Iterating Open Solutions for Different Practices, conducted in Ankara, Turkey (showing how groups exchanged open design solutions and practices).

6.1. The Structure of Workshop 2 and Generative Tools Used

The sharing pattern (Figure 82) for Workshop 2 is different than the one used in Workshop 1. First of all, the participants were divided into four groups of three. In this sharing pattern, while the design solutions were exchanged, each group only developed and iterated open solutions for their own practice. With this sharing pattern, the aim is to see how open parts developed for one practice can be utilized for different practices. In this workshop structure, similar steps were followed (see *Section 5.1. The Structure of Workshop 1 and Generative Tools Used)* with changes to tools, and an additional tool.

<u>*Changes in Step 1:*</u> Following the feedback from participants in Workshop 1 and the analysis of it, the Practice Timelines were developed further to include Practice Phases (i.e. Preparation, Cooking/Processing, Serving, Maintenance and Storing). These phases aim to help participants to recall and reconsider their kitchen practices more easily and in detail. Furthermore, there is only one timeline on each paper, as the groups only need to recall one practice, but develop three different solutions for it. Thus, they envision three different versions of the same practice, through their open solutions.

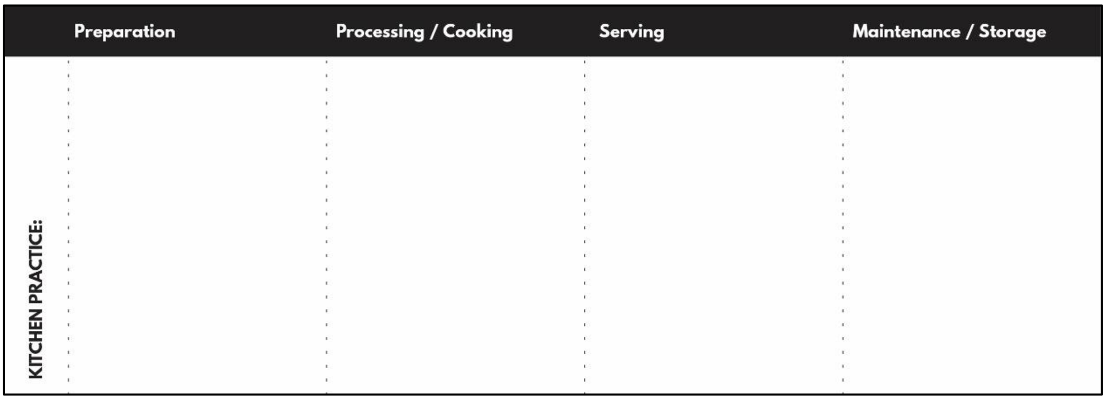

Figure 83. An example of the empty Practice Timeline provided during Workshop 2.

Sustainability Considerations Cards have changed as well, due to the previous experience in Workshop 1. There were two sets of cards (i.e. dark and light): the dark ones are focused on how parts need to be assembled and sourced (Figure 84), and the light ones indicate other design considerations related to maintenance, personalization and feedbacks (Figure 85). Two more considerations are added as dark cards, *individual skills for production* and *local skills for production*, which are associated with the produce phase in the *analysis of existing concerns and explorations*. These two were not included in the first workshop as I thought the participants wouldn't be able to explore these considerations, because they wouldn't be able to produce parts out of actual materials and they might not have knowledge on existing local possibilities or individual production opportunities. However, throughout the analysis of Workshop 1, comments on local and individual production were made, and this led me to add these considerations.

The front sides of the cards have the names and short explanations of the considerations, while the backsides have examples for each one and explanations on how these examples are related to the considerations. Through these examples, the aim was to make it easier for participants to understand design considerations and understand ways on how they can respond to those considerations. All the consideration cards prepared for this workshop can be found in *Appendix E – Print-Ready Consideration Cards for Workshop 2.*

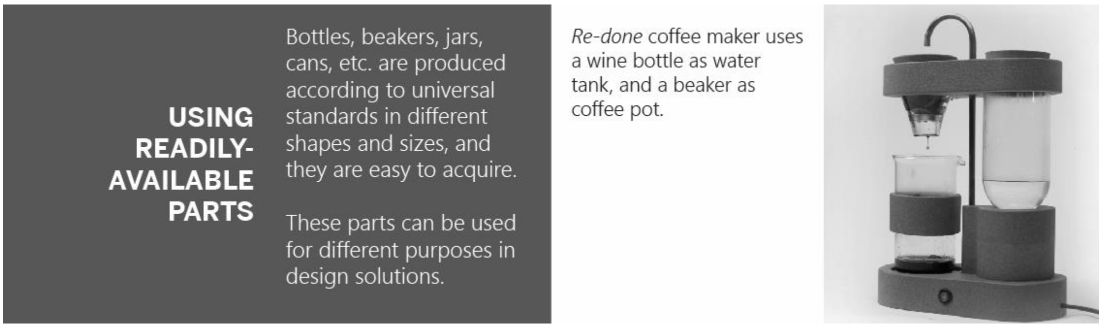

Figure 84. Sustainability Consideration Card for Using Readily Available Parts.

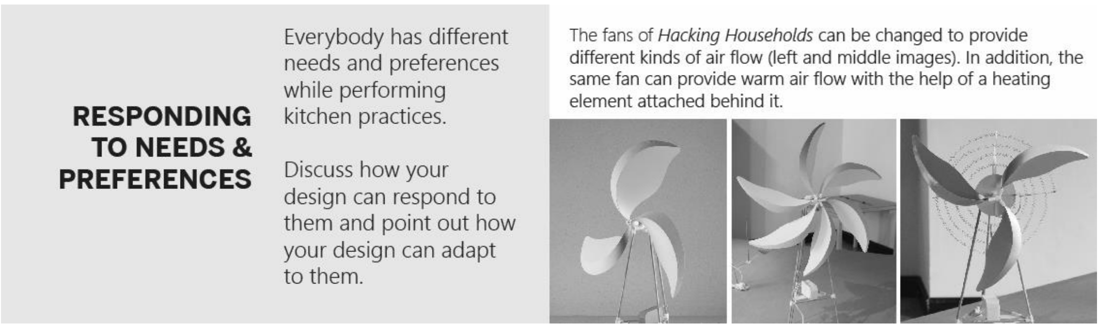

Figure 85. Sustainability Consideration Card for Responding to Different Needs and Preferences.

<u>*Changes in Step 2:*</u> In this step, an additional tool was added as a part of sharing the design solutions with other groups. The groups are asked to tag their part designs according to their "openness" and by whom they are produced. This was to enable the participants to explore and identify potential stakeholders for each part and related it to local skills and individual skills considerations. For this purpose, the stickers in Figure 86 were developed and given to the participants. These stickers helped them think about how their part designs will/can be produced and what kind of parts will/can be reused with every iteration. The suggested classification is simplified to make it easier for participants to understand the properties of different parts: (1) reused open part, (2) reused closed part, (3) closed part acquired from local retailer, (4) locally-produced open part, and (5) individually-produced open part.

Figure 86. Part Stickers for tagging part designs developed during the workshop.

These stickers are small and rectangular; they can be temporarily fixed onto part designs and be easily removed. They are meant to be used while preparing 3D posters, as seen in Figure 87.

Figure 87. Use of Part Stickers on developed part designs.

Apart from these changes, the procedure for the second workshop is very similar to the first one. It should be noted that the sharing pattern in this workshop is not better or more refined than the initial workshop; however, it presents complimentary qualities to explore product/part longevity, personalization and part reuse.

6.2. Outcomes of the Workshop 2

In this section, the outcomes of the second workshop and their analysis with respect to design considerations and open part properties are presented. For each iteration, what the participants intended are given, and then the open parts that were designed for that iteration are shown and explained. Following the explanation of developed solutions, the part properties and how they respond to sustainable design considerations are explained. Upon presenting every iteration in a track, an assessment on how the open design process responds to the concerns of the study through reused parts among iterations for different practices. Finally, the results of the analysis of all four tracks are brought together with open, sustainable design flowcharts developed before in *Section 4.3. Understanding Open, Sustainable Design Processes for Kitchen Practices* and *Section 5.3. Conclusions for Workshop 1: Iterating Open Solutions for Same Practice*. The chapter is concluded with a reflection on the workshop process, the outcomes and the implications of open design process for sustainability, and how it complements the results of Workshop 1.

6.2.1. Open Solutions of Track 1: Starting with Making Omelets

6.2.1.1. Initial solution on Making Omelets

The initial solution of Track 1 was developed by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu with the purpose of combining cooking and serving phases of omelet making, and easing flipping the omelet while cooking. Through analyzing their practices, they realized flipping the omelets was hard and has the tendency to end up breaking and spilling the ingredients on the kitchen counter and the outer surface of pans. Hence, they developed the double pan solution in presented Figure 88. The open solution has a little number of parts: two pans that are slightly different in size and can be closed on one another easily and pan handles (Figure 89).

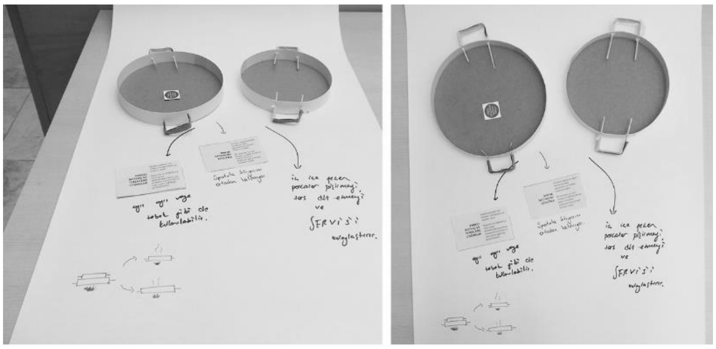

Figure 88. 3D poster of the Initial Solution of Track 1: Making Omelets, by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu.

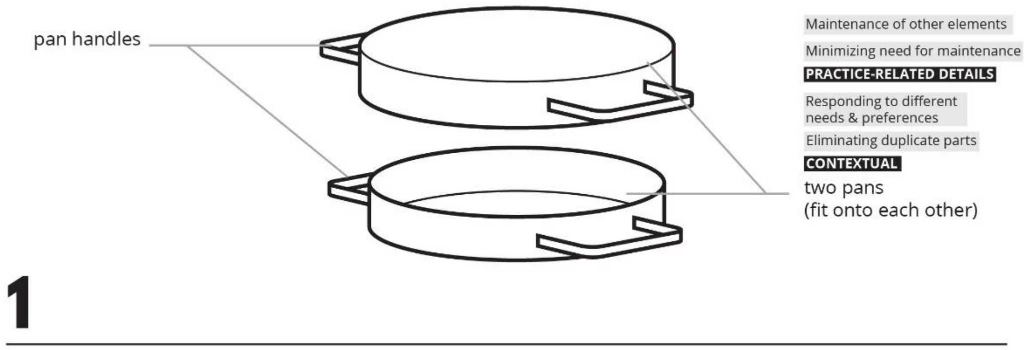

Figure 89. Illustration of the Initial Solution of Track 1: Making Omelets, by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu.

The changes in their omelet making practice was straightforward: Instead of using a spatula, they just flip the pans when they were fitted into one another. Through this *practice-related detail*, they prevented any spilling onto the kitchen counter or oven hub (i.e. *maintenance of other elements*) and onto the pans outer layer (i.e. *minimizing need for maintenance*). They also mentioned that the pans can be used separately to cook different ingredients in different *contexts* according to their *needs and preferences*, or they can be used as serving plates as well, *eliminating* the use of additional plates. It should be noted that, the participants suggested that all the parts in this solution should be mass produced to ensure quality and dimensional accuracy.

6.2.1.2. 2nd Iteration on Making Crepes

The second iteration of Track 1 was developed by Özge Özkök, Belis Su Alper and Esra Kıygın. In this iteration, the participants focused on the similar problem of flipping crepes as they have identified through the analysis on their practices of making pancakes and crepes. However, they also wanted to develop a stand-alone appliance. Consequently, the open solution in Figure 90 was developed, which is a double-sided crepe cooker. The solution consists of the pans of the initial solution, long handles, heating elements, heating plates and electric plug (Figure 91). In this iteration, the pan handles of the initial solution were abandoned and long, one sided handles were developed as they were found more suitable.

Figure 90. 3D poster of the Second Iteration of Track 1: Making Crepes by Özge Özkök, Belis Su Alper and Esra Kıygın.

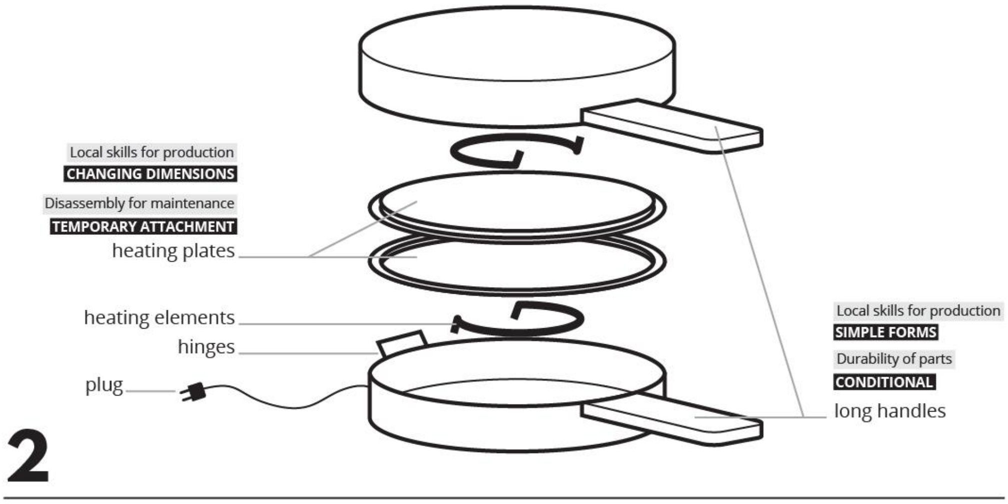

Figure 91. Illustration of the Second Iteration of Track 1: Making Crepes, by Özge Özkök, Belis Su Alper and Esra Kıygın.

As can be seen in Figure 91, this solution took into account three considerations. The heating plates can be *disassembled for cleaning* after use, since they are *temporarily attached*. The long handles were selected to ease the crepe cooking practice, as the practice did not require additional pressing of heating plates. The participants mentioned that if additional force needed to be applied (i.e. *conditional*), the long handles would not have been appropriate for this solution, as they could break (i.e. *durability of parts*). In addition, the participants thought these handles could be *produced locally* thanks to their *simple forms*. However, they would require certain durability which calls for skills of the local professionals (e.g. craftsmen). The participants thought that the heating plates can also be *produced locally* to fit the slightly *different dimensions* of the pans. Heating elements and electric plug are *retail parts* that can be acquired locally, and all the parts can be brought together *locally* or *individually*.

The most interesting part of this iteration is the way they utilized the pans of the initial solution. Both the shape and the make of pans – due to their production methods – make them suitable and durable to contain a heating element. Some properties of the pans may be unnecessary for an appliance shell; however, they can be reused for different purposes and needs when they can no longer be used as pans (e.g. due to scratching on their surfaces).

6.2.1.3. 3rd Iteration on Preparing Grilled Sandwiches

The second iteration of Track 1 was developed by Seda Büyükvural, Elif İdemen and Özlem Duyan. In this iteration, the participants aimed to further develop the crepe cooker of the previous iteration to be able to grill sandwiches as well. Pressing down the ingredients by applying force and heat to them was defined as the basic necessity of preparing grilled sandwiches through their analysis of this practice, hence they developed the previous iteration further (Figure 92).

The parts of this iteration can be seen in Figure 93. The participants retained some of the parts from the previous iteration (i.e. pan/shell, heating elements, electric plug), altered the design of one (i.e. double-sided heating plates) and replaced long handles with one press handle. Additionally, they included heating plate releases for both heating plates.

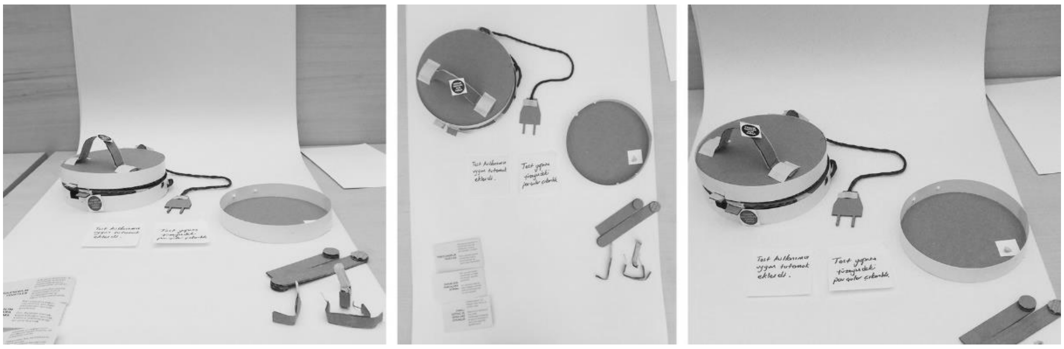

Figure 92. 3D poster of the Third Iteration of Track 1: Preparing Grilled Sandwiches by Seda Büyükvural, Elif İdemen and Özlem Duyan.

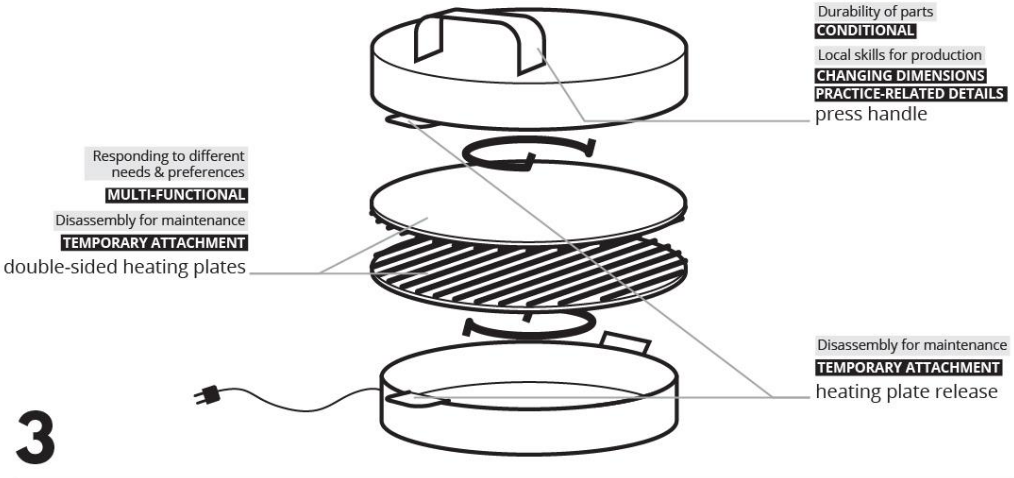

Figure 93. Illustration of the Third Iteration of Track 1: Preparing Grilled Sandwiches by Seda Büyükvural, Elif İdemen and Özlem Duyan.

The long handles of the previous iteration were replaced with a single press handle, as this practice requires a certain amount of force to flatten the ingredients of grilled sandwiches (i.e. *practice-related details*). That's why the press handle was placed on top of the upper body to ensure *durability.* The participants suggested that the press handle can be *produced locally* in *different sizes* matching the size of the pans and to ensure durability and quality. The double-sided heating plates are *multi-functional* as they accommodate both a flat surface and a corrugated surface that can be selected to *respond to different needs* of the user. In addition, these plates are also *temporarily attached* so that they can be *disassembled for cleaning* after use. The participants also added an additional heating plate release as the *temporary attachment* detail to *ease the disassembly,* since the heating plates tend to be hot after use and cannot be handled directly.

6.2.1.4. Reflections on Open Solutions of Track 1

In Track 1, I was able to observe how an open solution for making omelets transform into solutions for making crepes and making grilled sandwiches. Table 16 lists the open parts designed in every iteration and how they changed among iterations. The part property columns are to indicate the property of the open part that responds to open, sustainable design considerations. The dark gray cells on the table indicate the open parts that were changed or added.

Table 16. Open Parts designed for Track 1.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Two pans	Contextual, Practice-related details	Appliance bodies	-	Appliance bodies	-
Pan handles	-	Long handles	Simple forms, Conditional	Press handle	Practice-related details, Conditional, Changing dimensions
		Hinges	-	Hinges	-
		Heating plates	Temporary attachment, Simple forms, Changing dimensions	Double-sided heating plates	Multi-functional, Temporary attachment
		Heating elements	-	Heating elements	-
		Electric plug	-	Electric plug	-
				Heating element release	Temporary attachment

The initial solution had two pans that fit into each other, and pan handles. Using two pans in this manner was a practice-related detail for making omelets, however the shape and make of the pans enabled them to be used as appliance bodies in the following iterations. The handles were altered with each iteration as well. In the second iteration, the way the handles need to be located changed (i.e. instead of lifting pans, the second iteration required handles to operate the hinges). In the third iteration, since force needed to be applied on the upper appliance body, the location and shape of the handle were changed again.

Since the pans were utilized as appliance bodies in the second and third iterations, additional surfaces for cooking were required, hence heating plates were added accordingly. However, to enable maintenance of these elements, they were *temporarily attached*. The heating plates of second iteration focused only on crepe making, while it was replaced by *multi-functional* heating plates that can accommodate both crepe making and grilling sandwiches.

The most important change among these iterations is the utilization of parts (i.e. pans) for a complete different purpose (i.e. appliance bodies). This was only possible due to the features of the part that made it suitable for another purpose, and brings forward a different strategy for reusing open parts. Through the assessment of its features, pans were found appropriate to be utilized as appliance bodies according their shape and materials. I will call this strategy *abstractive*, as the open parts are assessed for reuse independent of their intended use. As discussed in *Section 6.2.1.2. 2nd Iteration on Making Crepes*, such open solutions create an opportunity for reusing end-of-life pans and making use of their structural properties for a completely different purpose, and present an alternative process for reusing parts. The way the second iteration was adopted for the third iteration is *adaptive* in the sense that the open parts are simply replaced by a different version to respond to needs and preferences of practice at hand.

Other than the above-mentioned potential for reusing open parts, this track responded to and expanded the meaning of the sustainable design considerations. Developed open parts throughout the open design process provides various implications of explored open, sustainable design considerations. Table 17 summarizes these implications in definitions of these considerations through explorations in Track 1 of Workshop 2.

Table 17. Design Considerations used in Track 1 of Workshop 2.

Design Consideration	Evolving definition from Analysis of Existing Concerns and Explorations & Workshop 1	Implications for explorations for Track 1 in Workshop 2
Responding to different needs	solutions that can respond to changing needs and preferences through *output adjusting* electrical parts, or non-electrical parts which can be used differently in different *contexts*, which can *transform* the part assemblage for different needs, or enrich use with *practice-related details*.	solutions that can respond to changing needs and preferences through non-electrical parts which can be used differently in different *contexts*, or *multi-functional* open parts which can be used for different practices.
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and *multi-functional* parts or *practice-related details* that can reduce the number of parts to be maintained.	*practice-related details* that reduce the number of surfaces that might need maintenance (i.e. outer surfaces of pans).
Maintenance of the other elements	*practice-related* solutions to maintain other elements.	*practice-related* solutions (i.e. two pans) to eliminate the need of maintenance of other elements (i.e. kitchen counter)
Eliminating duplicate parts	reducing the number of electrical parts through *output adjusting*, and non-electrical parts through *contextual* or *multi-functional* parts.	non-electrical parts that can be used for different purposes (i.e. cooking vessel and plate) in different *contexts* (i.e. cooking and serving)
Disassembly for maintenance	enabling the maintenance of parts (e.g. container, brushes) and separating electrical and non-electrical parts to prevent water damage to electrical parts (e.g. motor) by bringing them together with *temporary attachments*, or easing maintenance through *practice-related details* that can disassembled.	enabling the maintenance of non-electrical parts (i.e. heating plates) through separating them from the electrical parts (i.e. heating element) with *temporary attachment* details
Durability of parts	deciding on how to iterate related open parts according to *conditions* (e.g. bigger pot requires double handles) that apply to those parts.	deciding on how to iterate related open parts according to *conditions* (e.g. if force needs to be applied, put a handle on same direction) that apply to those parts.
Local skill for production	understanding the capabilities local producers (e.g. craftsmen) and utilizing them empower the local economy.	enabling local production for open parts with *simple forms* that may require *different dimensions* according to other parts

6.2.2. Open Solutions of Track 2: Starting with Making Crepes

6.2.2.1. Initial solution on Making Crepes

The initial solution of Track 2 was developed by Özge Özkök, Belis Su Alper and Esra Kıygın for Making crepes. The open solution (Figure 94) was about preparing the crepe dough and portioning it while cooking. Recalling their practices, they realized that scaling of the ingredients and mixing them thoroughly were the most important issues of crepe making, hence they developed a mixer with a dedicated scaled, container.

Figure 94. 3D poster of the Initial Solution of Track 2: Making Crepes by Özge Özkök, Belis Su Alper and Esra Kıygın.

The open parts of this solution are illustrated in Figure 95. The container is transparent and the scaling lines are not only in millimeters, but also specific to crepe doughs (e.g. amount of flour, sugar, milk, etc.). The container lid – as a part of the motor housing – can scale the dough for one crepe. The motor housing includes a motor which is connected to the electric plug. The container is filled with ingredients as shown on scaling lines of the container, then placed on the motor and mixing blade, the ingredients are mixed by plugging the solution, and then crepe dough is portioned through container lid part.

The container is *multi-functional* with embedded scaling lines, which were designed to replace a simple crepe dough recipe (e.g. two glasses of flour, one glass milk, etc.). The participants realized that such formulation of scaling lines (i.e. with recipe scales like glass, spoon, etc., instead of millimeters) can *eliminate* the use of additional kitchen utensils (i.e. glasses). Similarly, the depth of the container lid can be used for scaling dough for one crepe in addition to guarding the blades (i.e. contextual), *eliminating* the need for an additional scoop. Through including such *practice-related details*, these parts can *minimize need for maintenance* through *eliminating parts* from the practice. However, it should be noted that the participants did not provide a solution to seal the shaft hole in the middle of the container lid, through which the ingredients can reach and damage the motor. Since the motor is placed below the container, and the container lid – as a part of the motor housing – is used to scale crepe dough in liquid form, this is an important detail that should have been reflected upon to prevent breakdown.

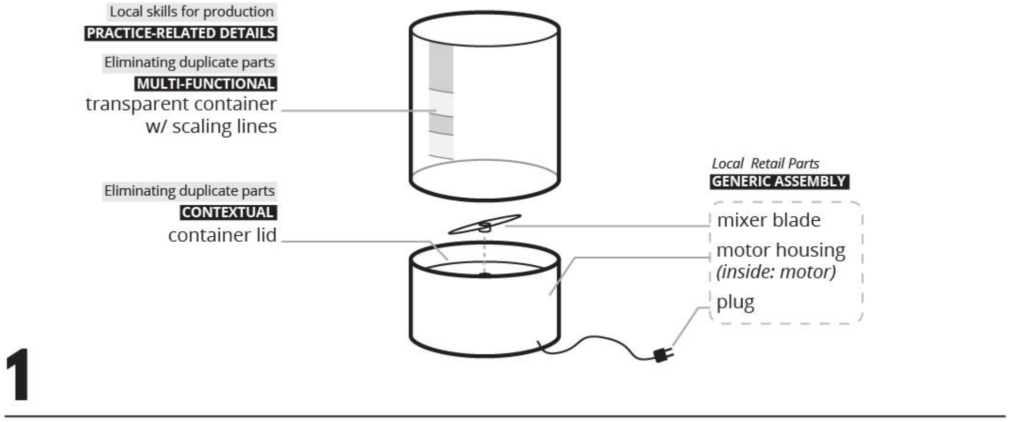

Figure 95. Illustration of the Initial Solution of Track 2: Making Crepes by Özge Özkök, Belis Su Alper and Esra Kıygın.

The participants stated that, motor, plug and mixer blade are local retail parts with *generic assembly* details, which can easily be brought together. They also stated that, since the container is designed with *practice-related* scaling lines, they may be *produced locally*, to accommodate different variations of the practice. *Local skills* were mentioned as important, as they may produce high-quality parts that can be used while cooking, yet unique parts that can respond to the needs of different individuals.

6.2.2.2. Second Iteration on Making Omelets

The second iteration of Track 2 was developed by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu to process the ingredients for omelets. Through their analysis of their own practices, they realized they put the ingredients on a pan in a certain order (e.g. onions first, paprika later, finally eggs) and they realized they can minimize need for maintenance with the help of a motorized tool and achieve “airy” omelets. Hence, they iterated the initial solution on crepe making further and developed the solution in Figure 96. The solution uses the same motor housing, but the container and blades are adapted according to their own practice. Additionally, they included silicone covers that can be used as omelet molds as well (Figure 97). The chopping blades are used to cut ingredients into pieces of desired size and the mixing blades are used to beat the eggs. Any ingredient processed is transferred onto the pan, and the next ingredient is processed.

Figure 96. 3D poster of the Second Iteration of Track 2: Making Omelets by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu.

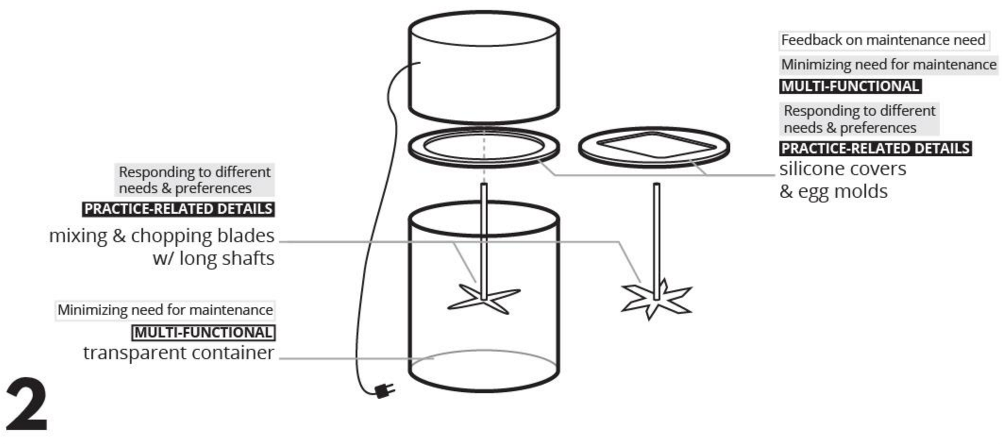

Figure 97. Illustration of the Second Iteration of Track 2: Making Omelets by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu.

The participants proposed two different blades as parts of their iteration, one for chopping the ingredients and another for beating the eggs (i.e. *practice-related details*) as they were crucial to *respond to different preferences* of users. The chopping blade can be rotated for different intervals to adjust the size of the ingredients and process food parallel to cooking times (e.g. chopping paprika until they need to be put on the pan). Silicone covers placed between the motor housing and container prevents ingredients from splashing on the inner surface of motor housing to *minimize need for maintenance*, and they can be removed and used on the pan as egg molds to *respond to different preferences*. Participants stated that the covers also give *feedback on maintenance* as well, as they are differently colored and can show if they are clean or not, however I believe this feature of silicone covers does not provide any kind of feedback more than a transparent container does. They also believe that the container *minimizes need for maintenance* through *eliminating the need* for a cutting board and additional containers to hold ingredients until cooking, however the number of parts used during the process does not change (i.e. cutting board, additional container, knife and whisker against container, chopping blade, mixing blade and silicone covers). As for how this iteration is produced, the participants only specified that the container can be produced locally, but did not state a reason for it.

6.2.2.2. Third Iteration on Baking Cakes

The third iteration of Track 2 was developed by Nesibe Kaya, Oğuz Boz and Ezgi Çakır to explore baking a different kind of cake. Reflecting upon the open parts they received, they developed the open solution in Figure 98 for making "mug-cakes" – the cakes that are baked and served in mugs or jars. As mentioned by the participants, this technique – baking cakes in glass jars – is a common practice in many cafés as the glass jars are resistant to the necessary temperature. As can be seen in the illustration (Figure 99), the open solution reuses the motor housing, silicone cover, mixing blade and electric plug of previous iterations, replaces the container with glass jars, and adds switches, a heating element and a heating element lid. The use of the open solution is straight forward: (1) mix the ingredients using the motor and mixing blade, (2) remove the mixing blade and heating element lid, (3) and bake the mug-cake using the heating element.

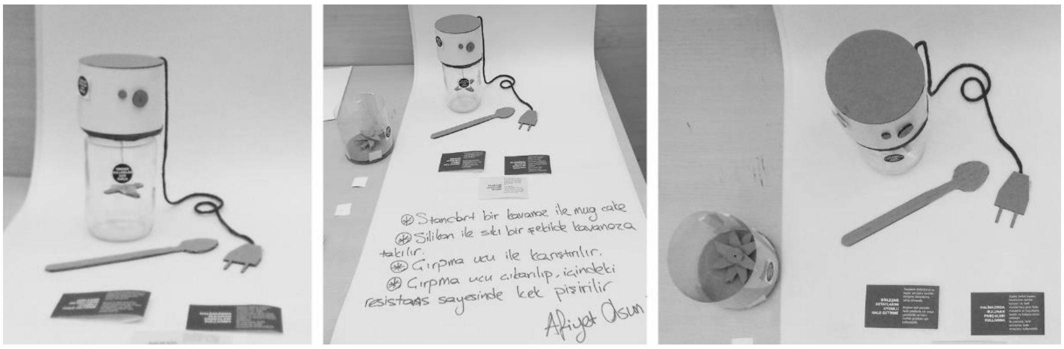

Figure 98. 3D poster of the Third Iteration of Track 2: Baking Cakes by Nesibe Kaya, Oğuz Boz and Ezgi Çakır.

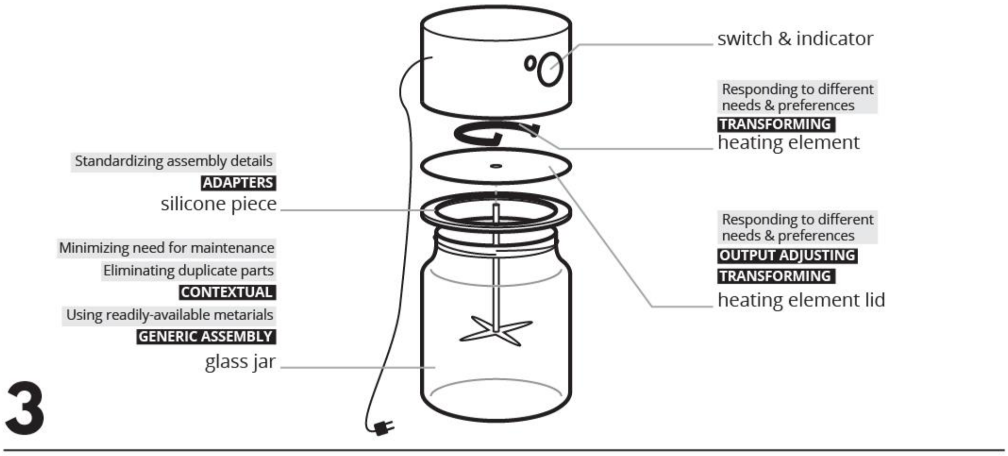

Figure 99. Illustration of the Third Iteration of Track 2: Baking Cakes by Nesibe Kaya, Oğuz Boz and Ezgi Çakır.

In this iteration, the container is replaced with a *generic* glass jar for two reasons: (1) glass jars are easy to acquire since they are *readily-available* and more than one mug-cake can be prepared, and (2) different sized jars can be used for different portions as long as they have similar diameters. In this aspect, the silicone cover of the previous iteration is used as an *adapter* to *standardize assembly details* for the motor housing to fit different glass jars. The participants also mentioned glass jars are used in *different contexts* (i.e. to mix, bake and serve), which *eliminates the need* for a mixing bowl, a cake mold and a serving plate, and *minimizes the need for maintenance*. The heating element and its lid has a *transforming* property in this solution, as they transform a tool for preparation to a tool of baking to *respond to the preferences* of users. The heating element is attached at the container lid space dedicated for measuring the crepe dough back in the initial solution and it is concealed with the *temporarily attached* heating element lid. The participants also mentioned that the heating element lid acts as a switch to *adjust the output*: Once it is removed the main switch operates the heating element instead of the motor.

6.2.2.4. Reflections on Open Solutions of Track 2

Table 18. Open Parts designed for Track 2.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Transparent Container w/ scaling lines	Multi-functional, Practice-related details	Transparent container	Multi-functional	Glass jar	Generic assembly, Contextual
Container lid	Contextual	Container lid	-	Heating element lid	Transforming, Output adjusting, Temporary attachment
Mixer blade	Generic assembly	Mixing & chopping blades	Practice-related details	Mixing blade	-
Motor housing	-	Motor housing	-	Motor housing	-
Motor	Generic assembly	Motor	-	Motor	-
Plug	Generic assembly	Plug	-	Plug	-
		Silicone covers/egg molds	Multi-functional, Practice-related details	Silicone piece	Adapter
				Heating element	Transforming
				Switch & indicator	-

The parts that were developed and iterated in Track 2 are shown in Table 18, presenting their part properties as well. The initial solution consists of a *multi-functional* transparent container with *practice-related* scaling lines, a mixer blade, a motor housing with a *contextual* container lid, a motor and a plug. In the second iteration, the design of the container is adapted and the scaling lines were abandoned, the design of blades changed to include a longer shaft as the direction of the whole appliance changed, and *multi-functional* silicone covers that also double as egg molds were included. In third iteration, the transparent container is replaced with a glass jar with *generic assembly details* (i.e. standard dimensions) that can be used in *different contexts*, and a *temporarily attached* heating element lid was added to cover the added heating element. The silicone cover of the previous iteration was used for completely different purpose as an *adapter* between the glass jar and the motor housing.

Table 19. Design Considerations used in Track 2 of Workshop 2.

Design Consideration	**Evolving definition from Analysis of Existing Concerns and Explorations & Workshop 1**	**Implications for explorations for Track 2 in Workshop 2**
Eliminating duplicate parts	reducing the number of electrical parts through *output adjusting*, and non-electrical parts through *contextual* or *multi-functional* parts.	non-electrical parts that can be used for different purposes in different *contexts* (i.e. preparation, cooking and serving) or through *multi-functional* properties (e.g. scaling lines).
Local skill for production	understanding the capabilities local producers (e.g. craftsmen) and utilizing them empower the local economy.	using local skills for open parts with *practice-related details* that may be different for different users.
Responding to different needs	solutions that can respond to changing needs and preferences through *output adjusting* electrical parts, or non-electrical parts which can be used differently in different *contexts,* which can *transform* the part assemblage for different needs, or enrich use with *practice-related details*.	solutions that can respond to changing needs and preferences through *output adjusting* electrical parts and non-electrical parts which can be used differently in different *contexts,* or enrich use with *practice-related details*.
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and *multi-functional* parts or *practice-related details* that can reduce the number of parts to be maintained.	*practice-related details* that reduce the number of surfaces that might need maintenance (i.e. outer surfaces of pans), and *multi-functional* or *contextual* parts that minimize the need for other utensils.
Feedback on maintenance need	solutions that conveys the need for maintenance to anyone using the open solutions	*multi-functional* parts that can show the maintenance need before and during use.
Using readily-available materials	using or reusing mass-produced and easy to acquire generic parts.	using mass-produced parts with *generic assembly details*, which can easily be acquired and replaced
Standardizing assembly details	using *generic assembly details* for open part designs or *adapter* parts so that wide-ranging open parts can be brought together to enable different part assemblages.	*adapter* part solutions that are used to bring together open parts with different solutions.

These iterations present different strategies for reusing open parts to carry out different practices. While new open parts (i.e. silicone covers/egg molds, heating element, switches) are added in each iteration (i.e. *additive*), some of them (i.e. container, blades) were adapted and/or replaced (i.e. *adaptive*) and one of them (i.e. silicone covers/silicone adapter) was simply reused for entirely different purposes (i.e. *abstractive*). This track that started with an initial solution for crepe making presented different strategies of altering open part designs for personalization and reusing them in different ways, to achieve part longevity. While open design process responded to the sustainability concerns of this study in such a manner, each iteration responded to sustainable design considerations with different implications, which are presented in Table 19.

6.2.3. Open Solutions of Track 3: Starting with Making Grilled Sandwiches

6.2.3.1. Initial solution on Making Grilled Sandwiches

The initial solution of Track 3 was developed by Seda Büyükvural, Elif İdemen and Özlem Duyan for making grilled sandwiches. Through the analysis of their grilled sandwich making practice, they realized the main problem was forgetting grilled sandwiches inside the appliance and burning them. Hence, they developed the design solution in Figure 100, which is a double conveyor belt grilling the sandwiches and pushing it onto a plate at the end. The solution consists of four legs, two conveyor belts and their drums which are positioned closer to each other on one end, two heating elements inside the conveyor belts, a control panel and an electric plug (Figure 101).

Figure 100. 3D poster of the Initial Solution of Track 3: Making Grilled Sandwiches by Seda Büyükvural, Elif İdemen and Özlem Duyan.

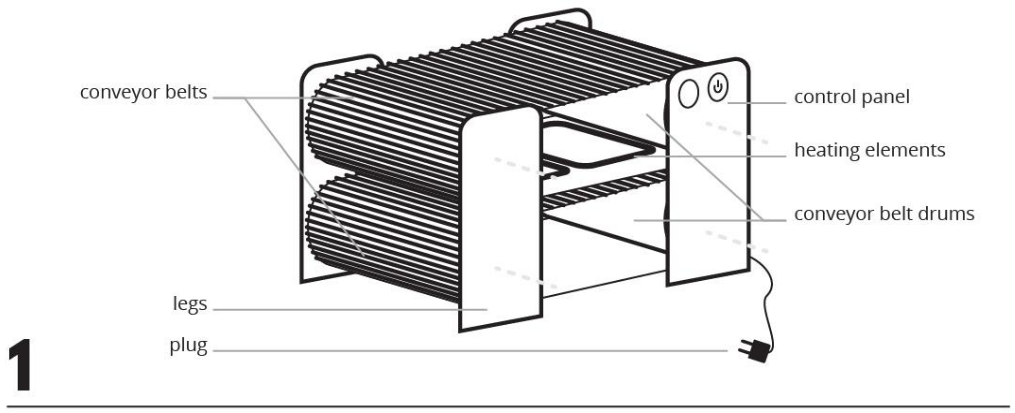

Figure 101. Illustration of the Initial Solution of Track 3: Making Grilled Sandwiches by Seda Büyükvural, Elif İdemen and Özlem Duyan.

Although the participants developed a unique design solution for grilled sandwiches. They mentioned that they have not taken any of the sustainable design considerations into account. When asked for the reason, they stated that they did not have the time to consider them as they were trying to come up with an innovative design solution. At this point, the purpose of sustainability considerations cards was explained once more as tools to facilitate idea-generation for open, sustainable design solutions. This explanation aided them to adopt this generative tool through the following steps of the workshop, as can be seen in other solutions developed for preparing grilled sandwiches presented in this section. All in all, the parts they developed were passed on to the next group.

6.2.3.2. Second iteration on Baking Cakes

The second iteration was developed by Nesibe Kaya, Oğuz Boz and Ezgi Çakır as a challenge to bake cakes through reusing the parts of the initial solution. Consequently, they developed the design solution in Figure 102, which is a standalone baking solution that is put directly on the cake mold. As illustrated in Figure 103, this iteration reuses the control panel, heating element and electric plug of the initial solution, utilizes one of the conveyor belts to create oven walls, adds a transparent lid to enable observation of baking process and handles to hold the solution.

Figure 102. 3D poster of the Second Iteration of Track 3: Baking Cakes by Nesibe Kaya, Oğuz Boz and Ezgi Çakır.

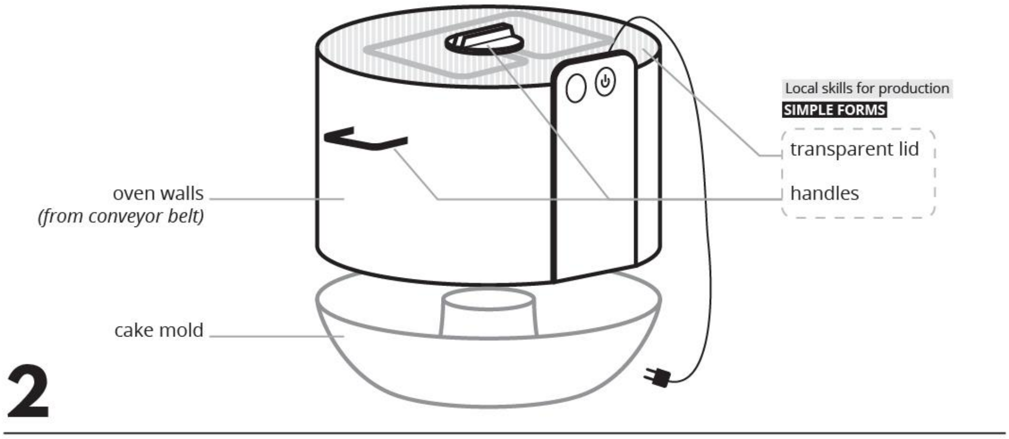

Figure 103. Illustration of the Second Iteration of Track 3: Baking Cakes by Nesibe Kaya, Oğuz Boz and Ezgi Çakır.

Throughout this challenge, they have only taken into account one consideration: *local skills for production*. Handles and transparent lid were designed with *simple forms* specifically to enable local production. In order to reuse parts, they have developed an experimental baking solution, which may require open parts specially produced to fit the salvaged parts of the initial solution.

6.2.3.3. Third iteration on Making Omelets

The third iteration of Track 3 was developed by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu with the purpose of minimizing need for maintenance through a new way of cooking the omelets. As a result, they developed a cooker with a separable glass cooking surface (Figure 104). The solution reuses glass lid, heating element, electric plug and a switch of the previous iterations, replaces the single handle of the lid with double-sided handles, and adds a heating element housing (Figure 105).

Figure 104. 3D poster of the Third Iteration of Track 3: Making Omelets by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu.

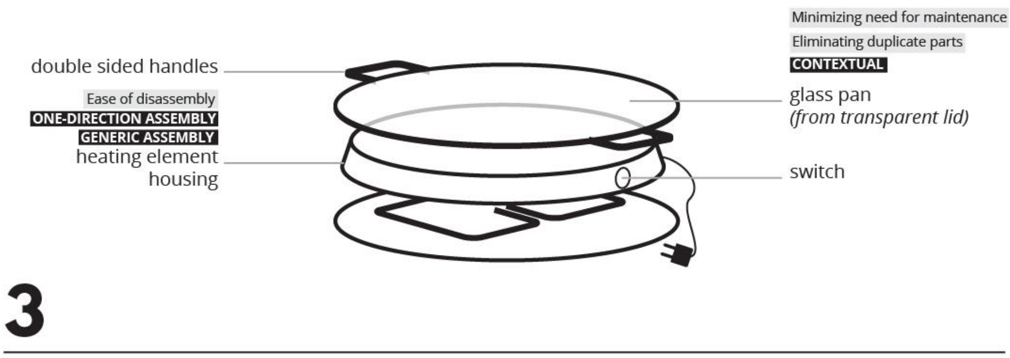

Figure 105. illustration of the Third Iteration of Track 3: Making Omelets by Serenay Tosun, Dilan Donat and Lilyana Yazıroğlu.

The driving consideration to develop this iteration was *eliminating the need* for an additional serving plate, and consequently *minimizing need for maintenance*, by using glass cooking surface in *different contexts* (i.e. cooking and serving). The omelet (or any other meal) is cooked on the glass surface and served with the same surface. The glass was thought to be a proper material to carry out such a task due to its hardness, as it wouldn't get scratched easily and can be used for both purposes. However, the participants did not consider the appropriateness of a flat glass surface for cooking, which may not ideal for keeping the ingredients while stirring.

The heating element, switch and electric plug are brought together to create an electric cooker with the help of a housing, which is assembled together with *generic assembly* *details* (e.g. screws) from *one direction* so that it could be *easily disassembled* for repair later.

6.2.3.4. Reflections on Open Solutions of Track 3

The parts that were developed and iterated in Track 3 are shown in Table 20, presenting their part properties as well. The initial solution for making grilled sandwiches consists of conveyor belts, their drums, a control panel, heating elements, legs and a plug. None of the parts were attributed with part properties that respond to sustainability considerations. In the second iteration for baking cakes, one of the conveyor belts was adapted as oven walls, control panel, one of the heating elements and electric plug were reused, and a transparent lid and a handle with *simple forms* were added. In the third iteration, only the heating element, electric plug and a switch from the control panel were reused, transparent lid was adapted for a different purpose as a glass cooking surface, and a heating element housing was developed.

Table 20. Open Parts designed for Track 3.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Conveyor belts	-	Oven walls	-	-	
Conveyor belt drums	-	-		-	
Control panel	-	Control panel	-	Switch	-
Heating elements	-	Heating element	-	Heating element	-
Legs	-	-		-	
Electric plug	-	Electric plug		Electric plug	
		Transparent lid	Simple forms	Glass cooking surface	Contextual
		Handles	Simple forms	Double handles	-
				Heating element housing	Generic assembly, One-direction assembly

Throughout these iterations, an *abandoning* of parts can easily be observed, as the open part designs for each practice could not be utilized in the following iterations. This resulted in very disparate open solutions, reusing only basic parts throughout the open design process (i.e. heating element and electric plug) without significantly changing their purposes or designs. Some parts are *abstracted* in very interesting manners, like conveyor belt for oven walls and transparent lid for cooking surfaces. Overall, this track developed many open parts that could not be reused in the following iterations for different practices, resulting in many of them being discarded. In addition, sustainability considerations were neglected in the initial solution of this track, hence only the ones presented in Table 21 were responded throughout Track 3.

Table 21. Design Considerations used in Track 3 of Workshop 2.

Design Consideration	**Evolving definition from Analysis of Existing Concerns and Explorations & Workshop 1**	**Implications for explorations for Track 3 in Workshop 2**
Local skill for production	understanding the capabilities local producers (e.g. craftsmen) and utilizing them empower the local economy.	part designs with *simple forms* that can be produced locally.
Eliminating duplicate parts	reducing the number of electrical parts through *output adjusting*, and non-electrical parts through *contextual* or *multi-functional* parts.	non-electrical parts that can be used for different purposes in *different contexts* (i.e. preparation, cooking and serving).
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and *multi-functional* parts or *practice-related details* that can reduce the number of parts to be maintained.	*contextual* parts that minimize the need for other utensils, consequently minimizing the maintenance need.
Ease of disassembly	solutions that allow the disassembly of each part separately through *one-direction assembly* for post-use processes.	solutions that allow the disassembly of each part separately through *generic assembly details* and *one-direction assembly* for post-use processes.

The reason for not incorporating sustainable design considerations in the initial solution was revealed in the group discussion at the end of the workshop (more generally explained in *Section 6.2.5. Group Discussion in Workshop 2*). Even though the facilitators intervened several times during the development of the initial solution on making grilled sandwiches, the participants stayed focused on creating an innovative solution for grilling sandwiches and neglected the given design considerations. It can be argued that *abandoning* of parts is the result of this neglect. However, it is also interesting to see that most of the initially developed parts (i.e. conveyor belt, drums and legs) that didn't respond to the design considerations in the initial solution were abandoned by the 2nd iteration, leaving only standard electrical parts (i.e. heating element, switches, electric plug).

6.2.4. Open Solutions of Track 4: Starting with Baking Cakes

6.2.4.1. Initial solution on Baking Cakes

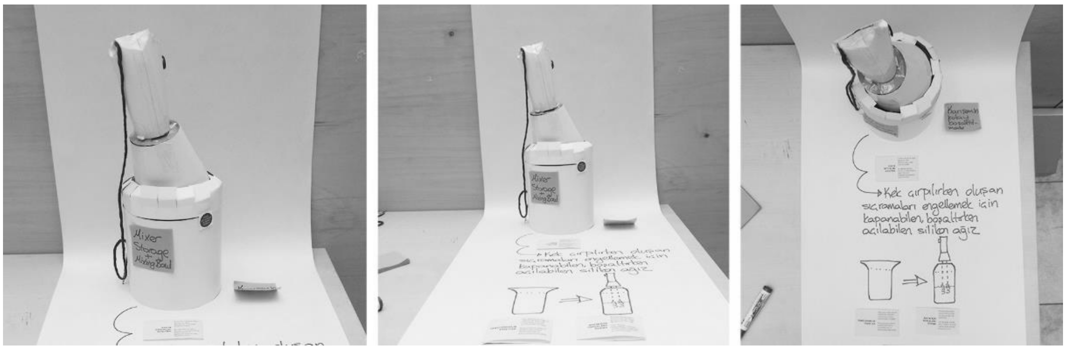

Figure 106. 3D poster of the Initial Solution of Track 4: Baking Cakes by Nesibe Kaya, Oğuz Boz and Ezgi Çakır.

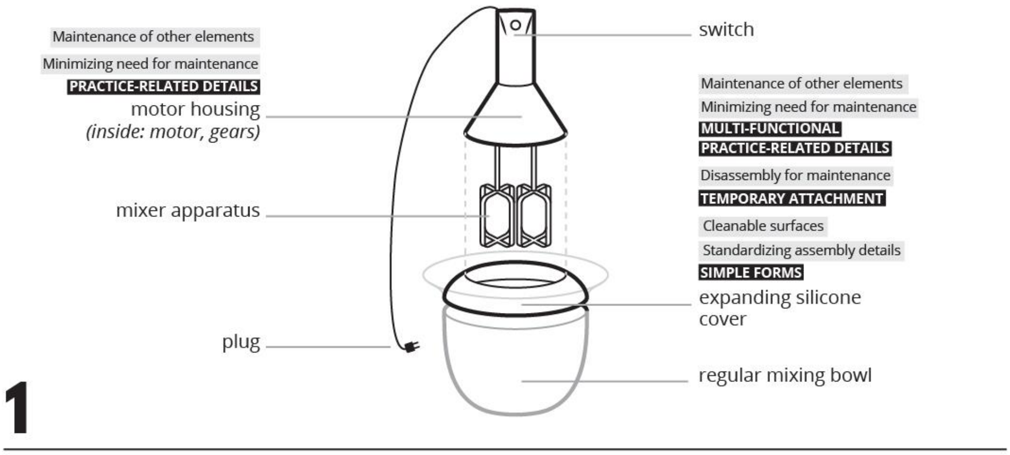

Figure 107. Illustration of the Initial Solution of Track 4: Baking Cakes by Nesibe Kaya, Oğuz Boz and Ezgi Çakır.

The initial solution of Track 4 (Figure 106) was developed by Nesibe Kaya, Oğuz Boz and Ezgi Çakır to prepare cake dough without splashing any of the ingredients on the kitchen counter or the outer surface of the mixing bowl. This was pointed out as the biggest issue they face when preparing the cake dough as the ingredients are in powder form and they can easily scatter around the kitchen. The solution consisted of a motor housing that enlarges towards the bottom – with motor and gears inside, mixer apparatus, an expanding silicone cover with opening that matches the diameter of the bottom of the motor hosing, a switch and an electric plug (Figure 107). The silicone cover is put on a regular mixing bowl of certain diameter, the ingredients in it are mixed with the help of the motor, and the silicone cover expands to ease pouring the dough onto a desired cake mold.

The motor housing enlarges towards the bottom to prevent splashing of ingredients on the kitchen counter or onto the motor housing itself. The matching silicone cover was developed with that purpose as well, and during use they completely close of any openings. These are *practice-related details* to minimize need for *maintenance of the solution and its surrounding* afterwards.

Apart from that, the silicone cover expands – with the help of a surface detail and elasticity of silicone material, which the participants could not represent with mock-up materials – as well (i.e. *multi-functional*), so that the cake dough can easily be poured into a cake mold without dripping it onto the kitchen counter or flowing over to the outer surface of the mixing bowl. It was developed with a *simple form* to ensure that it can fit onto basic bowls (i.e. *standardizing assembly details*), as well as for users to be able clean it easily. It is also *temporarily attached*, so that it can be *disassembled for cleaning* and the mixing bowl itself can be easily cleaned.

6.2.4.2. Second Iteration on Making Grilled Sandwiches

Through assessing the initial solution of Track 4, Seda Büyükvural, Elif İdemen and Özlem Duyan developed a compact, one-sided toaster solution (Figure 108). The idea is to grill sandwiches on the plate it will be served, one side after the other. This iteration reuses the motor housing of the previous iteration to house a heating element, the switch and electric plug, adds a corrugated heating plate and reuses the silicone cover of the previous iteration as a stand for the whole solution (Figure 109). The mixer apparatus, motor and gears are discarded in this iteration.

Figure 108. 3D poster of the Second Iteration of Track 4: Making Grilled Sandwiches by Seda Büyükvural, Elif İdemen and Özlem Duyan.

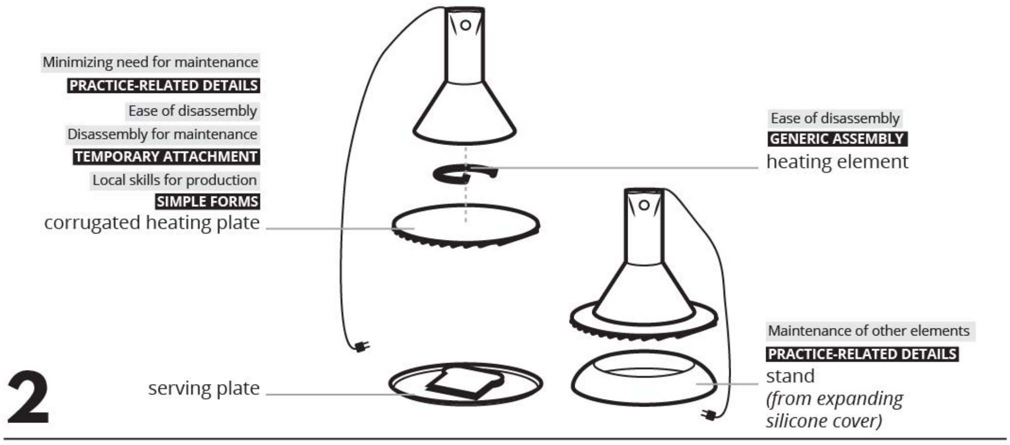

Figure 109. Illustration of the Second Iteration of Track 4: Making Grilled Sandwiches by Seda Büyükvural, Elif İdemen and Özlem Duyan.

Using one corrugated heating plate for this practice, and grilling the sandwiches on the serving plates, is a *practice-related detail* that merges cooking and serving stages of the practice and *minimizes need for maintenance*. This is due to two reasons: there is only one heating plate and it is above the ingredients – nothing will leak onto it. The heating plate is *temporarily attached*, so that it can be *disassembled for cleaning*. This property also *eases the disassembly* of parts, as there is only a heating element left attached behind the heating plate, which needs to be assembled with *generic details* for the same purpose.

It should be noted that, for even heat diffusion, this heating plate has a different shape (i.e. circular) compared to the heating plates on the market (i.e. rectangular). Hence, this part should be *produced locally* in a small scale. That’s why participants believed it should have a *simple form* that can easily be *produced with local skills*.

Since the heating plates stay hot a while longer after the practice is finished, it needed a stand (i.e. *practice-related detail*) in order to prevent it from harming the counter. For this purpose, the silicone cover of the initial solution was reused as a stand in this iteration, because silicone is resistant to heat and the shape of the part affords this usage.

6.2.4.2. Third Iteration on Making Crepes

Figure 110. 3D poster of the Third Iteration of Track 4: Making Crepes by Özge Özkök, Belis Su Alper and Esra Kıygın.

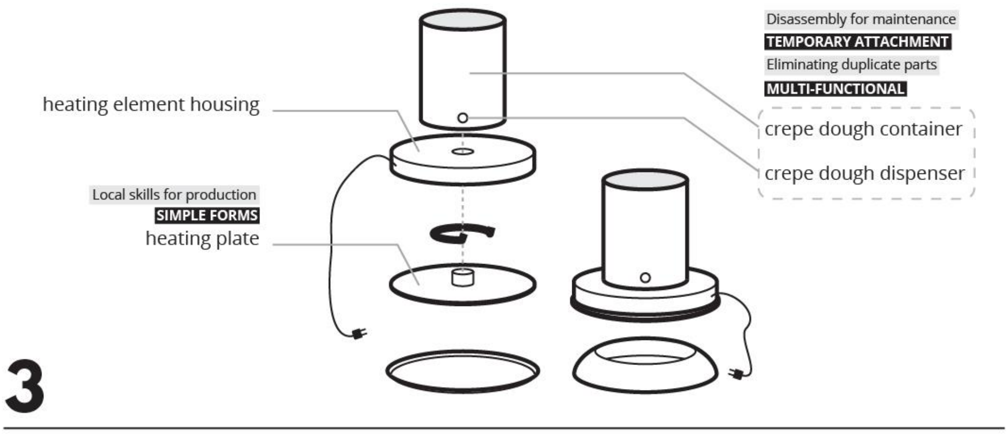

Figure 111. Illustration of the Third Iteration of Track 4: Making Crepes by Özge Özkök, Belis Su Alper and Esra Kıygın.

The third iteration of Track 4 was developed by Özge Özkök, Belis Su Alper and Esra Kıygın. Inspired by the previous iteration, they developed a solution to portion crepe dough and cook it on the serving plate (Figure 110). The iteration reuses the heating element, electric plug and silicone stand of the previous iteration, replaces the motor housing with a heating element housing and a crepe dough container and dispenser. The corrugated heating plate is replaced with a plain heating plate that is more suitable for cooking crepes (Figure 111).

The crepe dough is filled into the container from top and released with the dispenser from the bottom and through the heating element housing, onto the plate. The container can be used to mix the ingredients of crepe dough as well. Crepe dough container and dispenser is a *multi-functional* open part that *eliminates* the need for a scoop for portioning. The container is *temporarily attached*, so that it can be *disassembled for cleaning* after use. Similar to the previous iteration, the heating plate is unique in form, and needs to be produced in smaller quantities. Thus, it was designed with a *simple form* to be *produced locally*.

The participants thought that crepes are flat and do not require space to rise, hence the cooking technique developed for the previous iteration seemed appropriate for them. However, this also limits the usability of this solution for very similar kitchen practices (i.e. preparing pancakes) which may need space to rise. For example, while cooking pancakes, the user will need to hold the overall solution in air until the pancake rises. Hence, this iteration may require further development to incorporate other kitchen practices that are carried out in similar ways.

6.2.4.4. Reflections on Open Solutions of Track 4

The parts that were developed and iterated in Track 4 are shown in Table 22, presenting their part properties as well. The initial solution consists of a motor housing with a unique form (i.e. enlarging towards the bottom) related to preparing cake dough, a matching, temporarily attached, expanding silicone cover with a simple form, a motor and gears inside it, mixer apparatus, a switch and an electric plug. The second iteration for making grilled sandwiches reuses the motor housing to house a heating element – instead of a motor and gears – with a corrugated heating plate temporarily attached to it. This iteration also reuses the switch and electric plug of the previous iteration, and repurposes the silicone cover as a stand. Serving plate is also an important part of this practice, as the whole practice is carried out on it. The third iteration for making crepes replaces the motor housing for a heating element housing and a *multi-functional, temporarily attached* crepe dough container/dispenser. The corrugated heating plate is replaced with a plain heating plate that is more suitable to crepe making.

Table 22. Open Parts designed for Track 4.

Iteration 1		**Iteration 2**		**Iteration 3**	
Open Part	**Part Property**	**Open Part**	**Part Property**	**Open Part**	**Part Property**
Motor housing	Practice-related details	Motor housing	-	Heating element housing	-
Motor & gears	-	Heating Element	Generic assembly	Heating element	Generic assembly
Mixer apparatus	-	Corrugated heating plate	Simple forms, Temporary attachment, Practice-related details	Plain heating element	Simple forms
Switch	-	Switch	-	Switch	-
Electric plug	-	Electric plug	-	Electric plug	-
Expanding silicone cover	Simple forms, Temporary attachment, Practice-related details	Stand	Practice-related details	Stand	Practice-related details
		Serving plate	-	Serving plate	-
				Crepe dough container & dispenser	Multi-functional, Temporary attachment

These iterations are *additive* in nature, as they add new parts (e.g. heating element, corrugated heating element, crepe dough container/dispenser) to conform the needs of each practice. On the other hand, in each iteration there are parts that are *abstracted* from their initial purpose and repurposed according to their shapes and materials (e.g. motor housing, silicone cover). Also, some of the part designs were *adapted* to better carry out practices (e.g. corrugated heating plate to plain heating plate). This track shows an interesting combination of *additive*, *abstracting* and *adaptive* strategies of open design process and how open parts can be reused for different needs and preferences. Apart from these, each iteration responded to several sustainability considerations as well, implications of which are presented in Table 23 in comparison to the evolving definitions of these considerations.

Table 23. Design Considerations used in Track 4 of Workshop 2.

Design Consideration	**Evolving definition from Analysis of Existing Concerns and Explorations & Workshop 1**	**Implications for explorations for Track 4 in Workshop 2**
Minimizing need for maintenance	solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and *multi-functional* parts or *practice-related details* that can reduce the number of parts to be maintained.	*practice-related details* that reduce the number of surfaces that might need maintenance (i.e. outer surfaces of mixing bowls or motor housing).
Maintenance of other elements	*practice-related* solutions to maintain other elements.	*practice-related* solutions that prevent spillages (e.g. ingredients) or burning (e.g. from heating plates).
Disassembly for maintenance	enabling the maintenance of parts (e.g. container, brushes) and separating electrical and non-electrical parts to prevent water damage to electrical parts (e.g. motor) by bringing them together with *temporary attachments*, or easing maintenance through *practice-related details* that can disassembled.	enabling the maintenance of parts (e.g. heating plates, mixing bowls) and separating electrical and non-electrical parts to prevent water damage to electrical parts (e.g. motor) by bringing them together with *temporary attachments*.
Cleanable surfaces	solutions with *simple forms* void of unreachable details to ease their maintenance.	solutions with *simple forms* void of unreachable details to ease their maintenance.
Standardizing assembly details	using *generic assembly details* for open part designs or *adapter* parts so that wide-ranging open parts can be brought together to enable different part assemblages.	*adapter* part solutions that are used to bring together open parts with different solutions.
Ease of disassembly	solutions that allow the disassembly of each part separately through *one-direction assembly* for post-use processes.	solutions that allow the disassembly of each part separately through *temporary attachment* details for post-use processes.
Local skill for production	understanding the capabilities local producers (e.g. craftsmen) and utilizing them to empower the local economy.	part designs with *simple forms* that can be produced locally.
Eliminating duplicate parts	reducing the number of electrical parts through *output adjusting*, and non-electrical parts through *contextual* or *multi-functional* parts.	non-electrical parts that can be used for different purposes through *multi-functional* properties (e.g. crepe dough dispenser).

6.2.5. Group Discussion in Workshop 2

During the group discussion conducted at the end of Workshop 2, the insights of the participants on the design process their experiences, sharing open design solutions and the implications of open design process for sustainability were discussed. The discussion revealed participants' informed thoughts about the limitations and opportunities of both the workshop and the open design process for kitchen practices.

6.2.5.1. Designing and Generative Tools

The structure of the workshop was discussed in length, with regards to timing, generative tools and facilitator guidance.

- The generative toolkit eased the idea-generation process for participants, as it provided means to quickly build mock-ups to test ideas, as well as to understand how parts are designed and used in the previous iterations. Through physically building mock-ups, participants were able to develop their ideas further and present them in an easier manner.
- The workshop structure was mentioned as important for the facilitation of such a workshop. The participants believed that it was thanks to the detailed planning of the workshop that they were able to learn and experience open design in such a limited time. About the amount of time allocated to developing design solutions, some participants thought more time would make the process less tiring and more effective, while others thought more time was unnecessary as the results wouldn't be any different. It should be noted here that, this workshop was conducted in less amount of time then Workshop 1, due to the schedule of the conference it was conducted in, but this did not affect the time allocated for developing initial solutions and iterations. In this workshop, compared to Workshop 1, the participants did not need to reflect on different practices for every iteration as they always developed solutions for one practice. This also saved time during Workshop 2.
- Final topic on the workshop and its facilitation was about the facilitator guidance. The facilitators helped the participants resolve any kind of issue they faced while utilizing any generative tool, or when they are faced with mental

blocks. It was stated that the facilitators interfered when needed without limiting participants and helped them to move forward through workshop stages. This is an important feedback from the participants as the other two facilitators were not actively part of this PhD study. Their experience with generative tools and focus groups were also invaluable for the facilitation of this workshop. In return, I was able to lead the workshop in a timelier and effective manner, compared to Workshop 1.

While participants were mostly content with the workshop experience, they had pointed out some limitations about it as well, on lack of knowledge on open design and participants' backgrounds.

- While the presentation made at the beginning of the workshop was informative on open design, design knowledge sharing and sustainability concerns of the study, some of the participants felt that they couldn't reflect this new knowledge onto the initial solutions they developed. This is especially visible in the initial solution of Track 3, as the participants did not reflect on any design considerations, despite several interventions of the facilitators. When they were asked about the reason for this, they stated that they were trying to develop an innovative design solution, during which they were simply side-tracked and could not reflect on considerations.
- Although the workshop was open to all, it was conducted as part of a design conference and the participants mainly had design education background. Some of the participants suggested the inclusion of non-designers (e.g. engineers, social scientists, housewives, etc.) would have yielded different results. This is an important limitation that needs to be taken into account in further studies.

6.2.5.2. Sharing Open Design Solutions

About sharing the design data and knowledge with other people so that they can adapt or implement them, the role of the designer and copyright issues were questioned.

- If the design solutions can be created and shared by anyone, the participants were critical about the existence of design profession, as everyone will become informed about the design process. It was noted that the capabilities of a designer as a professional was a specialized set of skills to create design solutions. On the other hand, designers don't have necessary skills or knowledge on other topics (e.g. business, practices of different localities, etc.). In this sense, sharing of design knowledge and data could be beneficial for their improvement to conform real life contexts.
- Ownership was mentioned as an issue of openly sharing intellectual information (i.e. design data) and letting it be altered by other people. Design solutions, innovations, bright ideas, etc. would not have any owners and freely disseminate for other people to use. This is an important issue that needs further investigation, which is currently explored under open hardware licenses (OHL) and Creative Commons.

On the other hand, sharing design data and knowledge with other people was mentioned as a powerful tool to initiate change in perspective, lifestyles and consumption patterns for a sustainable future. Dissemination of design data among individuals would create a calling for more people with different skills and backgrounds to be a part of this open design process, and can become a pillar of change. This aspect is further discussed on the relation of open design and sustainability.

6.2.5.3. Sustainability Concerns and Open Design Process

The participants stated that open design is a newly developing area to observe its implications for sustainability completely. They have discussed the potentials as well as the limitations of it for the sustainability concerns of the study (i.e. product/part longevity, personalization, maintenance, repair and part reuse), which are presented below.

- Part assemblages that can easily be disassembled and reassembled in different configurations were thought to create opportunities for responding to different needs and preferences of people, as well as keep responding to them while they change over time. However, the open parts should be designed accordingly by the contributors of this process, so that any combination of open parts will present this potential.

- If design-related knowledge is shared with everyone and every open part is produced, assembled and reassembled accordingly, it creates opportunities for repair and upgrading of part assemblages to elongate the life span of open parts, as well as for reuse of open parts for different purposes (i.e. abstraction) to give them a second life. One of the participants called the latter the "reincarnation of parts", as they continue to live as something else.
- Concerns about reusing any open part designed for a certain part assemblage in a different assemblage were mentioned. With regards to functionality, reusing an open part shouldn't mean giving up on certain features needed or preferred for a practice. With regards to aesthetics, a part whose form was developed in accordance with the other parts of an assemblage would look discordant in a different assemblage. These concerns need to be taken into account at the very early stages of designing open parts.

On the other hand, participants also pointed out other concerns and opportunities that affect the implications of open design for sustainability:

- Some of the parts designed in Workshop 2 were only suitable for mass-production and trying to produce on a local or individual scale would not only be hard and demanding, but also affect the overall quality and reduce the effective life span of parts. Hence, the participants questioned how anyone should decide which part to produce individually or locally, and which part to acquire through retail channels. Hence, the discussion evolved into a consensus on a need for differentiating between mass-produced open parts that can be brought together with open, locally or individually produced parts. At this point, individual production was also questioned as the participants weren't able to assess if something could be produced by an individual or not. That consideration was found vague; hence it was not addressed throughout the workshop.

- The importance of standardization of dimensions were brought forward for the above-mentioned integration of mass-produced and locally/individually produced open parts. For example, in the kitchen context, these referred to utensils with standardized lengths, openings with standardized diameters and containers of standard sizes.
- The security concerns were mentioned by some participants, as developing electrical design solutions for kitchen appliances and physically creating them can result in accidents during use, if the parts are not assembled properly. All the participants designed the open parts to *be assembled together by individuals* (i.e. users). However, especially with bringing together electrical parts, the intervention of professionals was found necessary.

As for the adoption of open design and openly sharing design-related knowledge, the participants had differing thoughts. Some of them believed such a movement towards open design is near impossible to achieve unless companies adopt and disseminate it. This runs the risk of open design becoming a part of the current economic model and represent a different kind of modularity in products and losing its potential for sustainable production and consumption. On the other hand, others believed the grassroots development of online communities is already empowering people to create and share design-related knowledge, and this movement can become more widespread in time to manifest its potential for a sustainable future.

6.3. Conclusions for Workshop 2: Iterating Open Solutions for Different Practices

The analysis of outcomes revealed different open part properties responding to sustainability considerations for each iteration, as well as different ways of iterating open part designs to address the sustainability concerns of the study. To conclude this chapter, I will first present the part properties utilized in relation to sustainability considerations responded. Then, I will reveal observed strategies of adopting open design solutions in relation to the sustainability concerns of study.

6.3.1. Open, Sustainable Design Considerations and Open Part Properties Explored in Workshop 2

The design explorations developed by the participants of Workshop 2 revealed new strategies open design process can respond to sustainability concerns of this PhD study, along with sustainable design considerations directly or indirectly related to these concerns and open part properties that can accommodate these considerations. In this section, I will briefly summarize these sustainable design considerations and how open part properties responded to them. Table 24 below shows all the sustainable design considerations used during the workshop and all the open part properties utilized to respond to them. The light gray highlighted considerations (i.e. individual skills for production, feedback on breakdown reasons) are the ones that were not explored in either Workshop 1 or Workshop 2. The empty dots show the open part properties utilized to respond to the corresponding considerations in Workshop 1, but not in Workshop 2. The light gray dots show the properties that were not explored in Workshop 1, but were utilized in Workshop 2. The black dots show the considerations that were utilized in both workshops. In addition, a new part property emerged in Workshop 2: *changing dimensions*.

Readily-available parts were used as they have *generic assembly* details, which ensures they can be replaced if broken or reused as long as other open parts accommodate them. *Generic assembly details*, *one-direction assembly* and *temporary attachment* were utilized to *ease the disassembly* of open parts and enable repair and reuse of parts. The use of *adapters* as a way to *standardize assembly details* was utilized twice in this workshop, as the open parts were reused for different practices with different open parts. Among the iterations, some open parts were replaced with others (e.g. long handle with press handle) according to some *conditions* (e.g. if there is a need or preference to apply force) to ensure their *durability* and prevent breakdowns.

Table 24. Design Considerations responded in Workshop 1 & 2 among all design considerations related to Open Part Properties used.

	One-direction assembly	Generic assembly details	Adapters	Contextual	Output Adjusting	Transforming	Practice-related details	Conditional	Multi-functional	Simple Forms	Temporary attachment	**Changing dimensions**
Standardizing assembly details		○	●	○								
Cleanable surfaces										●	○	
Minimizing need for maintenance				◍			◍		●			
Feedback on maintenance need									◍			
Feedback on breakdown reasons												
Ease of disassembly	●	◍									◍	
Responding to needs & preferences				●	●	○	●		●			
Using readily-available parts		◍										
Eliminating duplicate parts				●	○		○		●			
Disassembly for maintenance											●	
Individual skills for production												
Local skills for production							◍			◍		◍
Durability of parts								●				
Maintenance of other elements							●					

○ Considerations explored in Workshop 1, but not in Workshop 2

◍ Considerations explored in Workshop 2, but not in Workshop 1

● Considerations explored in both workshops

Similarly, when an open part is reused for a different practice, other open parts may need to be *produced locally* to match *changing dimensions* of reused parts. *Local skills for production* can also become necessary to produce some *practice-related details*. To this end, open parts with *simple forms* were developed so that they can be produced with *different local skills*. Different *practice-related details* are developed to *respond to different needs and preferences*, which makes *local skills for production* an important way to produce different practice-related details. In the case for electrical parts, *output adjusting* becomes important to respond to *different needs of different practices and preferences of individuals*.

Temporary attachment was also important for *disassembly for maintenance* consideration, to prevent water damage to electrical parts, as well as to be able to reach some surfaces that require cleaning. This is related to *cleanable surfaces* consideration to elongate the lifespan of open parts and to make them reusable. *Simple forms* present itself as an important property for that matter, referring to surfaces void of unreachable surface details. *Multi-functional* parts are thought to be useful to provide *feedback on maintenance need*, as those parts will be used for different purposes and will be closely examined during use. *Multi-functional* and *contextual* parts are thought to *minimize need for maintenance* as well, because those parts will be used for different purposes during the kitchen practice before they are cleaned. This consideration is closely related to *eliminating duplicate parts*, since *multi-functional* and *contextual* parts eliminate the need for additional kitchen utensils. Some *practice-related details* can also help *minimize need for maintenance,* if they are developed with a careful analysis of the practice. Similarly, such details can be developed to *maintain other elements* (e.g. kitchen counter) if the practice requires it.

Two sustainable design considerations were not explored in both workshops: *Individual skills for production* and *feedback on breakdown reasons.* As mentioned in *Section 6.2.5.3. Sustainability Concerns and Open Design Process*, *individual skills for production consideration* was found vague as the participants could not assess the level of skills different individuals have. That's why, this consideration could not be incorporated into the idea-generation and reflected upon in the open solutions. As for *feedback on breakdown reasons* consideration, it was not mentioned in any of the group discussions. The possible reasons for not incorporating this consideration can be participants' lack of knowledge in possible breakdown reasons for the parts, or using representational parts and building other parts out of mock-up materials. In the end, these considerations remained unexplored in any of the workshops, which should be considered more in depth for any further studies.

These relations between open part properties and sustainable design considerations present implications for different yet interconnected concerns of this study. While some of them are directly related to elongating the lifespan of open parts individually through maintenance and repair, some of them are about ensuring they can be reused in different part assemblages, and others are about being preferred to be reused as they would be in line with changing needs and preferences. In the next section, I will try to explain the new strategies emerged in Workshop 2 and how these concerns are addressed in open design process.

6.3.2. Flowchart of Sustainability Considerations and Part Properties for Open, Sustainable Design Process

The above-mentioned design considerations affect the open design process differently in elongating lifespans of open parts, enabling personalization and responding to changes in individual needs and preferences, and enabling their reuse in following iterations. Although open solutions respond to these considerations individually, the opportunities and limitations of open design process for sustainability present themselves in how they are transformed over time and how the open parts are reused. Two strategies of adopting open design solutions were explored in Workshop 1 (i.e. adaptive and additive), and one more emerged in Workshop 2 (i.e. abstraction). These strategies are represented through the changes done to a circle composed of four quarters in Figure 112.

An adaptive process includes changing the design of certain open parts to fit changing needs and preferences of different individuals or different practices. This process can involve the alteration of open parts physically, or replacing them with similar open parts of different properties. Since the part designs are openly shared and can be modified by anyone, this strategy creates opportunities to personalize open part designs. However, if the open part cannot be altered physically in real life conditions, the old open part would be discarded and the new part would be assembled.

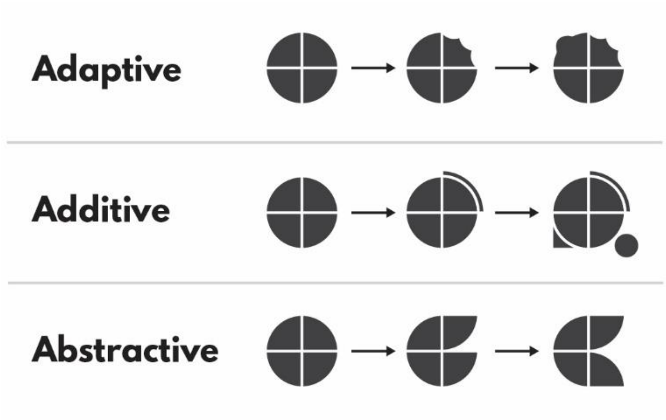

Figure 112. Different strategies of adopting open design solutions emerged from Workshop 2.

An additive process is about introducing new open parts to an initial solution to fit the changing needs and preferences of different individuals and practices. In this process, the initial design solution is reused as a whole and new open parts are added to the assemblage to respond the needs and preferences of individuals. The reuse of all initial open parts while responding to the changing needs and preferences seems desirable considering the concerns of this study; however, the capabilities of the initial open solution in comparison to what an individual needs and prefers should be questioned as well. If the initial open solution is an all-purpose solution to respond to all possible needs and preferences, there will be many unused or underused open parts.

An abstractive process is an interesting strategy emerged in Workshop 2 to reuse open parts in different iterations. It involves the reuse of open parts for purposes other than what they were initially designed for. Through assessing their features (e.g. material, shape, etc.) some open parts can be reused in different assemblages, for different purposes. Although, it seems like an interesting way to reuse open parts, it also runs the risk of utilizing open parts of highly valuable materials or components to be underused. This strategy can facilitate the reuse of parts that would otherwise be disposed of, through careful assessment of their features and their potential second life.

Apart from these strategies, *abandoning* was also observed in this workshop, which was mostly visible in the explorations of *Section 6.2.3. Open Solutions of Track 3: Starting with Making Grilled Sandwiches*. As the participants developing the initial solution of this track did not respond to any of the sustainable design considerations, this track was problematic and the iterations eventually abandoned most of the initially designed parts. However, it was also interesting to see how the initially designed open parts that do not respond to the sustainable design considerations are pushed out of the open design process through other contributors' decision on incorporating sustainable design considerations, and replaced by ones that respond to these considerations.

Even though these strategies are explained separately, it should be noted that they are not utilized as such. As mentioned at the end of each track of Workshop 2, these strategies happen in a combination according to the open parts received and the needs and preferences of people. However, openness of design data and being able to manipulate it in an informed manner enables personalization and part reuse through these strategies and presents potentials in product/part longevity. There is no 'right' combination for these strategies that can be applied to every case, however *abandoning* open parts should be avoided as much as possible.

At the end of previous chapter, the continuity of the iterations was also mentioned as it was an observed outcome of Workshop 1 affecting the way design solutions are adapted (see *Section 5.3.2. Flowchart of Sustainability Considerations and Part Properties for Open, Sustainable Design Process*). The continuity observed in Workshop 1 was an insight on how people implement and adapt solutions for the same practice, however in Workshop 2, such continuity cannot be observed as the open parts and their iterations were used for different practices. The importance of continuity in order to understand the implications of open design process for product/part longevity, personalization and part reuse should be questioned. Continuity (i.e. branched or continuous processes) does not affect the sustainability concerns of this study directly, as any observed branched or continuous process can respond to these concerns with the strategies of adoption (i.e. additive, adaptive and abstraction) and through incorporating sustainable design considerations. As a result, the flowchart developed as a result will not try to represent the continuity of iterations.

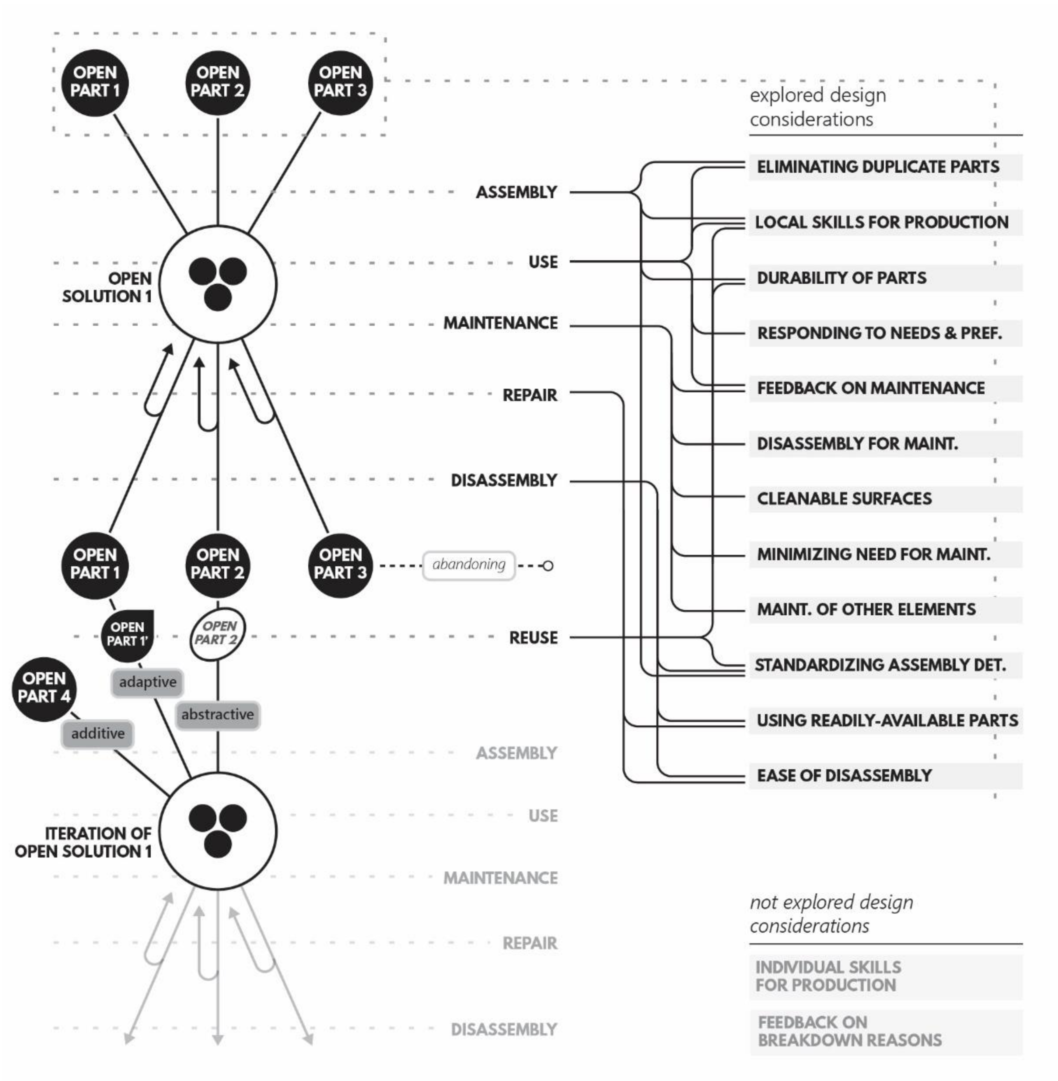

Figure 113. Open design process for kitchen practices emerged through the analysis of Workshop 1 and Workshop 2.

Figure 113 was developed as a result of analyzing the stories of open design solutions and their iterations in Workshop 1 and Workshop 2. The left side of Figure 113 represents how open parts and solutions are developed and iterated, along with strategies observed throughout these workshops (i.e. additive, adaptive and abstractive). The abandoning of parts was also placed here, as it was observed in the workshop. In the middle, the stages of open design process for sustainability are placed. On the right end side of Figure 113 are the design considerations that were developed throughout this PhD study. These considerations are related to open design for sustainability stages through the analysis of the stories of open design solutions and iterations. These stages are repeated, along with the flowchart, in light gray to indicate the continuous open design process.

It should be noted that, this flowchart is representational and does not completely reflect the whole aspects affecting open design process. It assumes open solutions consisting only of open parts, which may not be possible in real life contexts. However, it summarizes the relations between the design considerations and the stages of open design process, and strategies of adopting open design solutions.

6.3.3. Reflecting on the Application of Workshop 2

Workshop 2 was developed to explore how open solutions can be iterated for different practices (see *Section 5.3.3. Changes for the Next Workshop*). Through its application, a different strategy of adopting open part designs (i.e. abstraction) was observed, strategies observed in Workshop 1 (i.e. additive and adaptive) were further explored, and the implications of these strategies for concerns of the study (i.e. product/part longevity, personalization and post-use) were discussed. In this sense, the outcomes of Workshop 2 were complementary to Workshop 1, and enabled me to explore the implications of open design process for sustainability. From a methodological perspective, these two workshop structures should be used as complementary to explore design considerations and strategies of adopting open solutions for product groups and practices other than small kitchen appliances and practices shaped around them.

As for the sampling of Workshop 2, most of the participants were from a design background and the explorations were developed accordingly. The explorations were satisfactory and enabled the discussion on various aspects on the relation of open design process and sustainability. However, as mentioned in the group discussion as well, different outcomes might have surfaced, if the sampling was more diverse through the inclusion of social scientists, engineers, users, etc. In the future studies, the sampling can be diversified through a different sampling methodology (e.g. selective) to explore these strategies and considerations in relation to people with different backgrounds, particularly to understand the feasibility of these solutions. Nevertheless, this study enabled me to explore and present the relations between open design and sustainability. Further diversification of sampling can be useful to understand to what extent these relations can be constituted by non-designers is a topic for further studies.

CHAPTER 7

CONCLUSION

This thesis explores the implications of the newly emerging practice of open design for sustainability with regards to product/part longevity, personalization and post-use through a research study on kitchen practices shaped around small kitchen appliances. For this purpose, the following research questions were addressed:

1. What are the implications of open design to respond to the sustainable design concerns of this study [i.e. product/part longevity through post-use services (i.e. repair, part replacement, part reuse, upgrading) and personalization]? What are the opportunities and limitations of open design approach for these sustainability concerns?
2. What are the design considerations that can lead people who contribute to the open design process to design open, sustainable solutions for kitchen practices?
3. What are the properties of open part designs that respond to these design considerations and help achieve the sustainable design concerns of the study? How do these open part properties respond to the design considerations?
4. How can the design considerations and the responding open part properties be developed for a co-creation process like open design?

The answers to these questions build on top of each other, in reverse order. Hence, this chapter will answer these questions in the same fashion, continue with positioning this study within the existing literature and pointing out how people can benefit from its outcomes, and conclude with limitations of the study and opportunities for further studies.

7.1. Looking Back at the Research Questions

7.1.1. Methodological Contribution of the Study: For Research Question 4

Falling in line with the purpose of this thesis, which is exploring the implications of a certain design approach for sustainability, I wanted to adopt *research through designing* methodology that is a well-established approach in design research (see *Section 3.1.1. Research through Designing*). However, the design approach explored in this study (i.e. open design) is a kind of co-creation process that is theoretically never-ending, with diverse possible contributors, whose types and ways of contribution are widespread. This requires an approach different from the solitary representation of a designer-researcher in research through designing, who gathers data from literature, finds a way to apply the new perspective in design process and produces design outcomes, reflects on his/her design outcomes, and restarts the whole cycle again until he reaches a conclusion that presents practical and theoretical implications in line with his/her research questions. First of all, open design process involves many contributors that cannot be represented by a single designer/researcher. Secondly, the focus of open design is the *process* of sharing and adopting/adapting open solutions by different people, rather than the open solutions themselves. Hence, the exploration of open design *process* requires a reflection on the *process* as well as the *outcomes* as a whole.

Consequently, *research through co-designing* methodology has been developed through adapting the existing research through design framework in literature. *Research through co-designing* positions the designer/researcher as the facilitator of co-designing process through providing input from existing literature and the procedure for co-design process, in which various contributors develop and reflect upon their design solutions (i.e. reflection-in-action), and the designer/researcher reflects on the whole process (i.e. reflection-on-action), and this process repeats until fulfilling the main goals of the design research to present practical and theoretical knowledge. Using this research through co-designing framework, I have analyzed existing concerns and explorations on small kitchen appliances and behaviors shaped around them (*see* Chapter 4), and used the outcomes of that analysis in the two design workshops, which are structured as the emulations of open design process (*see* Chapter

5 and Chapter 6). The summary of overall steps taken throughout this study can be seen in Figure 114, on the right side of which *research through co-designing stages* are indicated.

The decision on using design workshops as a part of *research through co-designing* is an important part of the methodology of this study. Trying to observe and relate initial design solutions and their iterations in a process of continuously designing that has no limitation on when, where and with whom the process may continue is hard and time-consuming – if not impossible – within the limited amount of time of a PhD study. Hence, the design workshops conducted as a part of this study were important in (1) enabling me to follow and document how the initial solutions lead to different iterations, and (2) creating the environment to gather participants' reflections on open design process through experiencing it (or an emulation of it) first hand. Emulating the open design process in the form of design workshops was a feasible way to capture and analyze the stories of initial solutions and their iterations with regards to the sustainability concerns of the study, and how the individual solutions and iterations respond to sustainable design considerations.

Two complementary design workshops were developed and conducted throughout this study to explore two unique ways of iterating open design solutions. Workshop 1 was about exploring different contributors iterating an initial solution for the same practice, while Workshop 2 was about exploring different contributors iterating an initial solution for different practices. For the structure of Workshop 2, the similarities and differences among these practices may affect the process and the outcomes; hence, the sharing pattern for exchanging design solutions need to take this into account to ensure the diversity of solutions. In any further study to explore the implications of open design process, it is important to investigate both ways of iterating (i.e. iterating for same practice and iterating for different practices) to produce comprehensive research outcomes.

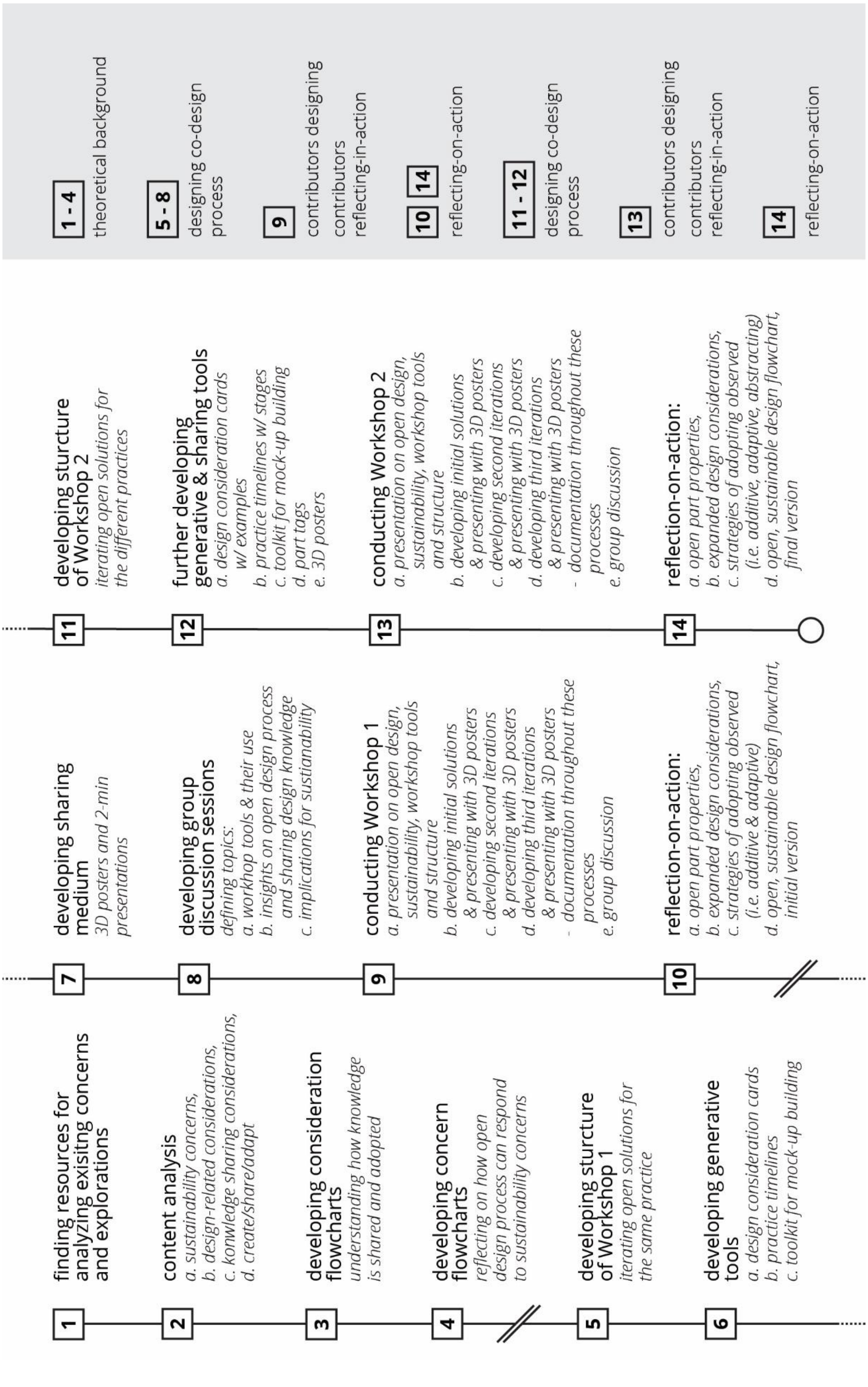

Figure 114. The summary of the design research stages of this PhD Study.

The design workshops were structured in a comprehensive way to include recurring designing solutions and reflection-in-action for developing initial solutions, and second and third iterations. The generative toolkit – emerged from the Experience Reflection Modelling (ERM) (Turhan, 2013) – was developed consisting of easy-to-process mock-up materials (e.g. cardboards, doughs, tapes, etc.), readily-available parts (e.g. jars, bins, cans, etc.) and representational laser-cut pieces (e.g. motors, blades, electric plugs, etc.) to help participants easily generate ideas and build physical models. Sustainability consideration cards for design-related considerations were developed to incorporate sustainability concerns of the study during idea-generation, and to enable participants to relate their solutions to these considerations while sharing them. 3D posters were used to communicate these relations between iterations as a sharing medium, which also enabled me to systematically document every design solution. On the other hand, the preparation of the 3D posters by participants enabled them to reflect on provided design considerations and their relevancy to the design solutions they developed. All these generative tools and detailed structuring of the workshops is crucial for data collection and analysis of the workshop outcomes.

Individually and *sequentially* analyzing the outcomes of the workshops is fundamental to understand the implications of open design for sustainability, as the potential of open design lies within the *process* and the *outcomes*. Hence, the changing parts among iterations, their properties and how these properties respond to sustainability considerations, and how the way these changes happen are related to the sustainability concerns of the study can be explored only when the stories of open design solutions and iterations are analyzed. That's why the workshops were analyzed and presented sequentially to make these changes visible (see *Section 5.2. Outcomes of the Workshop 1* and *Section 6.2. Outcomes of the Workshop 2*).

This research approach is one of the fundamental contributions of this study and an answer to the fourth research question (i.e. how to develop design considerations and responding open part properties for open, sustainable design process), as it allowed me to explore the implications of open design process for kitchen practices extensively, and to produce knowledge on both design process (i.e. the strategies of adopting open solutions and sustainable design considerations) and design outcome (i.e. open part properties responding sustainability).

7.1.2. Sustainable Design Considerations and Open Part Properties Explored: For Research Questions 2 & 3

In *Chapter 4 - Analyzing Existing Concerns and Explorations*, explorations, research projects and online platforms focusing on sustainability concerns of the study, open design and kitchen appliances were defined, and they were analyzed to reveal several *design* and *knowledge sharing related* considerations. These considerations are presented as flowcharts to present how open design knowledge should be created, shared and adapted, to inform and facilitate open design process. In the following stages of the study, only *design* considerations were incorporated in the design workshops to initiate idea-generation for each solution and their iterations, considering the workshop structure and the extent of what participants can explore within a limited time frame. In addition, only representational parts were used and/or created during the workshops, as they focused on the conceptual development of design solutions – using the generative toolkits developed and presented to the participants. Exploring *knowledge sharing related* considerations would only result in abstract knowledge with representational parts that do not have the functional features of the intended parts.

All in all, through the utilization of generative toolkits, the participants were able to quickly mock-up their design ideas, which they developed through the facilitation of sustainable design considerations. In Workshop 1, the design solutions were related to sustainable design considerations through recurring open part properties, which were thematically coded and presented (see *Section 5.3.1. Open, Sustainable Design Considerations and Open Part Properties Emerged from Workshop 1*). In Workshop 2, all these properties were found in the design solutions with an addition (i.e. *changing dimensions* property). In the end, twelve open part properties emerged which respond to the ten of the initially developed sustainable design considerations and two new considerations. These new considerations (i.e. *durability of parts* and *maintenance of other elements*) were defined throughout the analysis of the open design solutions presented in Workshop 1 and Workshop 2. The definitions of all explored design considerations were developed further with the open part properties coded and defined throughout the workshops and their manifestation as open part designs – which are presented in *Chapter 5 and Chapter 6*. Sustainable design considerations explored throughout this study and their definitions with open part properties can be found below in Table 25.

Table 25. Sustainable Design Considerations and their definitions expanded with open part properties explored in design workshops.

Standardizing assembly details	using *generic assembly details* for open part designs or *adapter* parts, so that wide-ranging open parts can be brought together to enable different part assemblages.
Cleanable surfaces	solutions with *simple forms* void of unreachable details to ease their maintenance.
Minimizing need for maintenance	*practice-related details* solutions to prevent spillages, overflows, etc. to eliminate extra maintenance for parts and *multi-functional* or *contextual* parts or *practice-related details* that can reduce the number of parts to be maintained.
Feedback on maintenance need	*multi-functional* parts that can show the maintenance need before and during use.
Ease of disassembly	solutions that allow the disassembly of each part separately through *one-direction assembly*, *generic assembly details* or *temporary attachment* details for post-use processes.
Responding to needs & preferences	solutions that can respond to changing needs and preferences through *output adjusting* electrical parts, non-electrical parts which can be used differently in different *contexts*, parts which can *transform* the part assemblage for different needs, parts which are *multi-functional* and can be used for different practices, or parts which enrich use with *practice-related details*.
Using readily-available parts	using mass-produced parts with *generic assembly details* which can easily be acquired and replaced
Eliminating duplicate parts	reducing the number of electrical parts through *output adjusting*, and non-electrical parts through *multi-functional* parts or pars that can be used in *different contexts*.
Disassembly for maintenance	enabling the maintenance of parts (e.g. container, brushes) and separating electrical and non-electrical parts to prevent water damage to electrical parts (e.g. motor) by bringing them together with *temporary attachments*, or easing maintenance through *practice-related details* that can disassembled.
Local skills for production	understanding the capabilities local producers (e.g. craftsmen) and utilizing them to produce *practice-related details* or parts that can fit *changing dimensions* that may be different for different users and practices, through part designs with *simple forms* that can be produced with those capabilities.
Durability of parts	deciding on how to iterate related open parts according to *conditions* (e.g. if force needs to be applied, put a handle on same direction) that apply to those parts
Maintenance of other elements	*practice-related* solutions to maintain other elements that are not directly related to the kitchen practice (e.g. kitchen counter, sink, etc.).

Although all the *design* considerations developed through the analysis of existing concerns and explorations were incorporated in the design workshops, two of them (i.e. individual skills for production and feedback on breakdown reasons) were not explored. *Individual skills for production* was addressed in the group discussion of Workshop 2, for having a vague definition as the skills of individuals vary greatly according their backgrounds and interests. This is an important input from the participants: Such a consideration cannot be utilized without a proper list of those individual skills. The initial explanation of this consideration in *Section 4.2.1.11. Individual Skills for Production* refers to production and assembly by individuals through the diverse set of skills, which can be separately addressed in other design considerations related to production and assembly. This is probably why the consideration was found vague and was not addressed by the participants. As for *feedback on breakdown reasons,* although it was not addressed in any of the group discussions, I suspect that it was not addressed, because the design process stayed conceptual with the representative parts, and the participants were not able to foresee possible breakdown reasons to develop feedback mechanisms about them.

The answer to Research Questions 2 and 3 produced these outcomes, very briefly summarized as Table 25 above. These sustainable design considerations and open part properties were developed for kitchen practices, and they can be used to generate sustainable open design solutions for product/part longevity, personalization and part reuse. Although each and every one of them cannot be directly linked to specific sustainability concerns, it should be noted that their collective inclusion to facilitate idea-generation of open solutions and their iterations steers participants towards developing open, sustainable design solutions.

7.1.3. Strategies of Adopting Open Design Solutions: For Research Question 1

Apart from the sustainable design considerations and open part properties, the sequential analysis of the open design solutions and their iterations revealed the ways of how initially developed open parts are reused and/or personalized throughout the open design process. These were called the *strategies of adopting open design solutions* throughout Chapter 5 and 6.

As a result of the workshop structure of Workshop 1 (see *Section 5.1. The Structure of Workshop 1 and Generative Tools Used*), *adaptive* and *additive* strategies were identified. *Adaptive* strategy involves altering the design of certain open parts of the previous solution to fit the needs and preferences of different individuals. *Additive* strategy adopts previously developed open parts and adds new open parts for the same purpose. Apart from it, a *continuity* among iterations was observed, as the workshop structure focused on iterating an initial solution for the same practice carried out by different individuals. *Continuous* and *branched* adoption patterns were observed in this workshop. *Continuous* pattern was similar to a normal product design process, as the ideas were consecutively developed while taking into account all the *adaptions* or *additions* done in the previous iterations. *Branched* pattern, however, discards some of the *adaptions* or *additions* in order not to include any parts or features more than the needed or preferred ones.

These strategies (i.e. *adaptive* and *additive*) were also observed in Workshop 2, and a new strategy was identified: *abstractive*. *Abstractive* strategy repurposes open parts and utilizes them for some other purposes rather than their intended ones, with regards to their shape, size, material and other features. As for *continuity,* those patterns (i.e. continuous and branched) could not be observed due to the workshop structure (see *Section 6.1. The Structure of Workshop 2 and Generative Tools Used*). The initial open design solutions were iterated for different practices which required them to be changed into different solutions in the first place. However, this workshop structure allowed me to capture another aspect of these strategies: they should be understood on the part level, instead design solution level. This is to point out that these strategies can be observed in different combinations according to the iteration being developed. Some open part designs can be *adapted*, while new open parts can be *added,* and some of the open parts can be repurposed through *abstracting*. These strategies need to be assessed along with the actual open part designs and the decision on how to iterate them should be made accordingly. Although the opportunities of these strategies were discussed in detail in previous chapters, Table 26 is prepared to summarize those discussions to easily compare them.

As mentioned before, these strategies can be utilized in different combinations to iterate the open design solutions at hand. It should also be noted that the decision on which strategies to utilize depends on the open parts available within the open design solution at hand and the intention of iterating them. There is no make-sure way of declaring the most prominent or the least effective strategy with regards to product/part longevity, personalization and part reuse. For each iteration, these strategies need to be assessed as opposed to the sustainable design concerns.

Table 26. Strategies of adopting in open design processes and their opportunities and limitations for product/part longevity, personalization and part reuse.

Strategies of Adopting	**Opportunities**	**Limitations**
Adaptive	Altering open part designs to fit individual needs and preferences, which may enable the reuse of open part through physical modifications.	If an open part cannot be modified physically, any alterations in its design would require part replacement, discarding the initial open part.
Additive	New open parts are added to the initial solution, so that it can respond to different needs and preferences.	Some redundant open parts that are not used in the next iteration are kept, instead of being reused in another design solution.
Abstractive	Rethinking what open parts can be used for other than what they were intended for, creating different opportunities to reuse open parts	If not properly assessed, abstraction can result in underuse of parts and/or materials, which can accommodate more than their newly assigned purposes in a new iteration.

7.2. Positioning this study

Literature on open design focuses on three distinct aspects: (1) contributors and their capabilities (Aitomurto *et al.*, 2015, Wolf *et al.*, 2014, Maldini, 2012, Stappers *et al.*, 2011), (2) processes and how open solutions can be created and iterated (Richardson, 2016, Tooze *et al.*, 2014), and (3) outcomes and protecting intellectual property rights of open to all solutions (Powell, 2015, Raasch *et al.*, 2009). These aspects are discussed in accordance to the opportunities they may create and the limitations they may present for sustainability in general (Bonvoisin, 2016, Kostakis *et al.*, 2015, Bauwens *et al.*, 2014). As for literature on design for sustainability, co-creation with different actors or stakeholders (i.e. producer, user, designer) (Manzini, 2015, Manzini & Rizzo, 2011, Buur & Lenson, 2010, Fuad-Luke, 2009) and the integration of different scales of design and production (i.e. from individual and local to mass-scale) (Shedroff, 2009, Doğan & Walker, 2008) are widely discussed and they are quite similar to what is implied by open sharing of design knowledge and their adoption by other contributors of the open design process. However, the implications of open design for more focused concerns of sustainability – like product/part longevity, personalization, part reuse – need to be explored beyond these similarities. Although the potential of open design to transition towards sustainable ways of living is mentioned in literature (Stikker, 2011, Thackara, 2011), this potential is not explored in practice, especially for established product categories (e.g. kitchen appliances). Furthermore, there is a lack of guiding texts or other resources that would help people understand and explore the potential relation between sustainability and open design process. This gap in the literature drove me towards conducting this study exclusively focused on exploring how the outcomes of open design process can implicate sustainable design concerns. This study is one of the first explorations in this area considering the implications of open design approach for sustainability – from a wider, methodological perspective to a focused level through sustainable design considerations for kitchen practices.

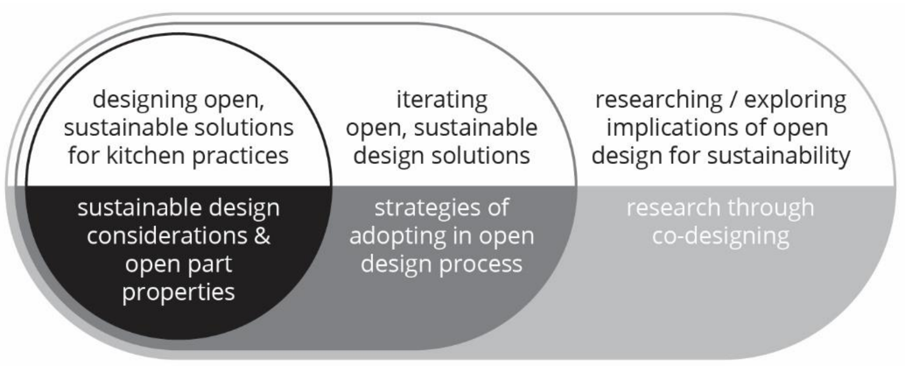

Figure 115. The outcomes, process and approach as the main contributions of this study.

Consequently, the outcomes of this study can be categorized into three, as can be seen in Figure 115. The sustainable design considerations and open part properties that respond to them can be used by anyone (e.g. designers, craft consumers, makers, small scale producers, start-ups, etc.) who wants to develop or iterate open, sustainable design solutions for kitchen practices shaped around kitchen appliances. The design considerations will enable contributors to reconsider key points that would enable their open design solution and its parts to be repaired and maintained, personalized and reused. The open part properties, along with the outcomes of the workshops as design explorations, will provide inspirational examples on how they can respond to these considerations while generating ideas. Although these considerations and part properties were meant to develop open, sustainable design solutions for kitchen practices, some of them (e.g. standardizing assembly details, eliminating duplicate parts, local skills for production) are useful for developing open solutions on different practices. All the considerations can be developed further through finding out their implications for different practices and may have the potential to become general considerations for open, sustainable design process for any practice or product.

The strategies of adopting in open design process will help contributors to understand how they can iterate any open design solution with elongating the lifespans of parts through personalization and part reuse. Through the stories of design explorations developed during the workshops, they will be able to assess and select the most appropriate strategies according to the open design solution they adopted, and the solution they want to iterate it into. Although these strategies were observed through solutions for kitchen practices, they are meaningful for other practices as well. Of course, the feasibility and applicability of these strategies for other product categories and practices need to be tested as well, through which new strategies may also emerge.

Research through co-designing framework and content analysis through cross relating sustainability concerns, considerations and open part properties will aid any researcher who aims to explore the implications of open design for different concerns of sustainability – or any other issue. Through utilizing the framework, the researchers can choose different data collection methods and tools, and analyze the data through their stories to capture the implications of a continuous and evolving design process like open design.

7.3. Limitations and Further Studies

As an exploratory study that adopt research through co-designing framework, this PhD thesis produced outcomes to inspire following research studies and practices related to open design and sustainability. The way it was carried out presents certain limitations, through which directions for further research can also be derived. The sections below present these directions.

7.3.1. Sustainability throughout the Open Design Process

The sustainable design considerations developed throughout this study aim to help contributors develop open, sustainable design solutions for kitchen practices. As mentioned in the group discussions by the workshop participants, and as can be seen in *Section 6.2.3.4. Reflections on Open Solutions of Track 3*, these considerations may not be adapted by the contributors of the open design process and result in open parts and solutions, which cannot be repaired, reused or altered. Although these parts can be pushed out of the open design process by other contributors that reflect on these design considerations, it is still a challenge to ensure that the contributors adopt these considerations.

Sharing design data and knowledge is a powerful tool to initiate change in perspective, lifestyles and consumption patterns, as it can inspire behavior change through sharing and the shared knowledge is flexible in the sense that it can be adapted for different social and cultural needs. On the other hand, the shared design knowledge is also vulnerable to be assimilated into the current economic model, representing a different kind of modularity and mass-customization (see *Section 2.2.4.5. Mass-customization*). Presenting sustainable design considerations for contributors of open design process help them to develop open, sustainable design solutions and share this open, sustainable design knowledge to inspire others. How to inspire more people and ensure them to adopt these considerations – and sustainability concerns, from a larger perspective – throughout the open design process is an important topic to be investigated in further studies.

7.3.2. Safety and Electrical Parts

This study focuses on kitchen practices shaped around small kitchen appliances and the design explorations developed by workshop participants has electrical parts (e.g. motors, heating elements). The safety of people dealing with electrical parts (i.e. assembling and disassembling, using, maintaining, repairing and reusing) is an important concern, which was mentioned in group discussions. In *Chapter 4 - Analyzing Existing Concerns and Explorations*, this concern was included in the explanations of considerations as important knowledge that needs to be shared with contributors. However, in an open design process with no limitation on the kind of contributions and the background of contributors, who will assess the reliability of security related knowledge and how they will assess it become important. This concern was highlighted in the group discussions as well, as the participants shared their doubts on wanting to actually build these solutions with working electrical parts and using them.

This is an important obstacle against the adoption of open design process, as there is no authority that will eliminate or reduce these safety concerns for altering shared open design knowledge. There are open hardware licenses (OHL) and commercially available open hardware, design data of which is shared, however these solutions cannot eliminate the safety concerns for every adaptation and iteration to their designs. Hence, in order for open design approach to be adopted more widely, the safety aspect and eliminating safety concerns in open design process should be investigated in further studies.

7.3.3. Sampling and Diversity of Participants

The sampling of the workshops was hard to reconcile between the theoretical background of open design and practical requirements of the research study at hand. Open design, by definition, is open to *everyone's* contributions, which I found crucial to be applied to all calls for workshops. Hence, all the calls were made open to public, with an indication saying “open to all” (see *Appendix F – Call for Participants to Workshop 1*). However, the topic of the workshops and their explanations were in parallel to the goals of this study, and attracted the participants mostly from design backgrounds (i.e. interaction design, service design, design history, industrial design, design management) and one from a different background (i.e. industrial engineer). This is, of course, no surprise given the topic and content of the workshops, and in this study focusing on the designing of open solutions and iterations, the workshop processes were dependent on participants' skills and knowledge to develop more relevant solutions.

However, the inclusion of people with different backgrounds is particularly important to explore *knowledge sharing related considerations*, as people from diverse backgrounds would perceive open parts they adopt through different perspectives accordingly. Hence, through defining the kinds of contributors from a theoretical standpoint on open design, a selective sampling method could be used for any further studies to explore knowledge-related considerations and their implications for open, sustainable design process. How people with different backgrounds can share design-related knowledge correctly, and how they interpret and adopt the shared knowledge can be explored only through including those people into the study. This is an important direction for further studies, as this study addresses how sharing open design solutions affect the sustainability concerns of the study, but not the way the design knowledge should be shared. Through such an inclusion of people with different backgrounds, further studies on (1) the feasibility of open design solutions and their iterations, (2) alternative business models for open, sustainable design process and (3) management of very diverse yet openly shared design knowledge can be conducted to investigate the adoption of open, sustainable design process in real life contexts.

7.3.4. Generative Toolkit of Representational Parts

For these workshops, a generative toolkit of representational parts made out of cardboard (e.g. motors, heating elements, knobs, switches, etc.) and additional mock-up materials to build different shapes and forms (e.g. cardboards, cylinder guides, wires, etc.) were used to facilitate the idea generation of conceptual design process and to engage the contributors in that process. This allowed the participants to easily hand over the design solutions they developed and iterated to the next group. This toolkit was useful for me to observe the changes among of conceptual open design solutions and iterations, as they could be developed within a limited amount of time in a controlled environment, and the outcomes of the workshops as mock-ups were useful to explore the sustainable design considerations and open part properties.

However, these mock-ups do not share all the functional features of actual parts made out of the intended materials and components (e.g. plastics, metal, wood, electrical parts, etc.), and they cannot be tested for actual using or post-use services. Using real materials to produce functioning open parts and iterating them will potentially shed more light onto sharing and altering part designs, and exploring their implications for product/part longevity, personalization and post-use. On the other hand, it will require a longer period of time than a one-day workshop to develop those parts, produce them and share them. Consequently, a research study on open design process with actual parts need to be structured in a meticulous manner, taking into account all potential outside factors, like acquisition of material, securing a fabrication facility (e.g. FabLabs), mapping local production possibilities (e.g. craftsmen, batch scale producers, electricians etc.), and so forth. This is another promising direction for further studies to understand the practical implications of both design related and knowledge sharing related considerations, and the strategies of adopting open design solutions for design, production, use and post-use.

7.3.5. Other Established Product Categories

This study was conducted with a focus on practices shaped around small kitchen appliances, and explored the potential of open design process to transform the small kitchen appliances product category. This focus was particularly fruitful for the purpose of this study (i.e. exploring open, sustainable design), because these practices – and these products – are commonly carried out in many homes. The participants were already experienced as users of these products, and they reflected on their experiences to develop the open design solutions during the workshops. In return, sustainable design considerations and responding open part properties for these practices were developed throughout the study, as well as more generalizable strategies for adopting open solutions.

However, the methodology of this study can be adapted for different established product categories through the practices shaped around them to explore the potential of open design process. Different open solutions for different practices would surely reveal *similar* and *different* sustainable design considerations and open part properties. Such studies may also reveal *additional* strategies that were not observed in this study. Through such studies, a separation between *practice-specific* and *general* open, sustainable design considerations and open part properties can also be made. Further studies in this direction can produce outcomes that would be useful to the contributors of open design process as well as the design researchers tackling with the relation of open design and sustainability.

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APPENDIX A – SUSTAINABLE DESIGN CONSIDERATIONS DEVELOPED IN TÜBİTAK PROJECT

Table 27. Sustainable design considerations developed in TÜBİTAK Project No:112M223.

PRODUCT MAINTENANCE	Perception	M1	Perception of durability	Product parts giving a sense of durability during use. *E.g.* Due to the perception that paper bag of a vacuum cleaner will be pierced or ripped, more durable dust bags/bins – like a fabric bag or a plastic bin – are suggested.
		M2	Perception of safety	Indicating the use and maintenance phases with feedbacks to give a sense of safety. *E.g.* While assembling the apparatus of blenders / choppers, a feedback – like a mechanical click sound – that indicates they were assembled correctly.
		M3	Perception of cleanliness	Surface properties that strengthens the perception of cleanliness. *E.g.* Instead of using materials that turn pale in time – like white plastics – in tea makers, other materials that retain their surface properties over time should be used – like colored plastics, stainless steel, etc.
	Ease and Safety of Maintenance	M4	Ease of cleaning the exterior	Enabling easy cleaning of the exterior of the product without the use of complex and / or hard cleaning methods. *E.g.* Reducing the number of indentations on surfaces and assembly details.
		M5	Ease of cleaning the interior	Enabling easy cleaning of the interior (i.e. surfaces that come into conduct with food, water, vacuumed dust, etc.) of the product without the use of complex and / or hard cleaning methods. *E.g.* The materials used and the form of grilling plates can prevent sticking of the food.
		M6	Number of parts to maintain	Reducing the number of parts that needs maintenance *E.g.* Replacing the drainer of tea makers with a draining surface attached to the spout eliminates the need for maintenance after every use.
		M7	Visibility / accessibility of product parts	User being able to see and access the parts that need maintenance. *E.g.* To be able to see, detach and re-attach the HEPA and sponge filters of vacuum cleaners.
		M8	Ease of assembling / disassembling the product parts	User being able to disassemble and re-assemble products consisting of various parts with ease for maintenance. *E.g.* disassembling and re-assembling the motor and apparatus of blenders / choppers through an easy-to-operate motor mount.
		M9	Promoting intended use	Promoting user behaviors that maintain the parts and products with care. *E.g.* Promoting the operation of blenders / choppers in intervals, instead of continuously, to prevent overheating.
		M10	Maintenance of fragile / electronic parts	Protecting the fragile and electronic parts against sloppy maintenance that may lead to issues of safety and breakdown. *E.g.* design details to prevent base connector to come into contact with water during maintenance.
		M11	User safety during maintenance	Preventing harm to the user during maintenance through design details. *E.g.* Isolation details to prevent skin burns when handling an electrical tea maker.
	Maintenance Intervals	M12	Visibility of maintenance schedule	Easing the tracking of and understanding the maintenance schedule for users. *E.g.* Showing how full the dust bag is in vacuum cleaners.
		M13	Keeping product parts clean	Enabling the user to keep the parts and product clean during use and easing the cleaning process for storage. *E.g.* users tend to use aluminum foil or baking paper in contact grills to keep the grilling plates clean.
		M14	Keeping use environment clean	Preventing the product parts to dirty the use environment. *E.g.* Re-thinking the spout of Turkish coffee makers to prevent coffee from spilling on the counter.
PRODUCT REPAIR	Ease and Safety of Repair	R1	Visibility of product failure	Presenting the location of and the reason for the product failure clearly. *E.g.* Understanding where the blockage is when the vacuum cleaner does nor suck air.
		R2	Ease and safety of disassembling the product parts	Easing the process of assembling and disassembling the product parts for repair *E.g.* Blender motor that can easily be disassembled in case of a failure rather than permanently attached ones.
	Preserving Product and Product Parts	R3	Promoting intended use	Enabling use behaviors or providing product features that may contribute to the product lifespan. *E.g.* automatically turning of the tea maker – or warn the user to turn it off – once the water level is lower than the minimum sign
		R4	Preserving surface properties	Surface details and materials that prevents scratches, de-coloring, etc. *E.g.* glass container for choppers, instead of a plastic one.
		R5	Durability of product parts and assembly details	Product parts that can endure long-term usage and wear *E.g.* durable vacuum cleaner hose that would not be ripped off when pulling the appliance.
		R6	Protection of fragile / electronic parts	Preventing failure of electronic and fragile parts during use and post-use. *E.g.* Design details to prevent the crushing of the power cord.

Table 27. Sustainable design considerations developed in TÜBİTAK Project No:112M223 (continued).

	Repair Service	R7	Providing repair service	Providing accessible and convenient repair services that offer affordable support. *E.g.* Local technical services providing fast and low-cost repair.
		R8	Availability of product parts	Accessibility of the product parts that need to be repaired, replaced or upgraded. *E.g.* Upgrading contact grill's cast iron plates with ceramic ones.
		R9	Compatibility of product parts	Product parts that are compatible with other products or different brands of the same product. *E.g.* Universal dust bags in vacuum cleaners.
EFFECTIVE USE OF RESOURCES	Understanding Resource Use	E1	Scaling of resources	Indicating the amount of resources (water, energy, etc.) consumed during diverse phases of product use. *E.g.* Water level indicators for accurate scaling of water in electric tea makers.
		E2	Visibility of the use phases	Demonstrating the use stages clearly through providing perceptible feedback. *E.g.* Temperature indicator on contact grills.
		E3	Visibility of the resources	Providing information or feedback regarding the resource consumption of the product *E.g.* on/off indicator showing if the product is using electricity.
		E4	Perception of resource consumption	Product features or use patterns leading an overall impression about resource consumption. *E.g.* comparing household appliances' duration of use to estimate their overall resource consumption.
	User Needs, Preferences and Behaviors	E5	Adaptability to the user needs and preferences	Adapting to different user needs and preferences to reduce resource consumption *E.g.* Temperature adjustment in electric tea makers to brew diverse teas.
		E6	Promoting intended use	Product features that reduce intensive resource consumption automatically or through informing the user. *E.g.* Time adjustment to reduce duration of use in tea makers.
	Resource Efficiency	E7	Enabling effective use of energy	Ensuring the energy is not wasted during product use. *E.g.* Pausing the vacuum cleaner while relocating the furniture.
		E8	Enabling effective use of water	Ensuring the water is not wasted during product use. *E.g.* Automatic scaling of water in coffee makers.
		E9	Effective use of the product capacity	Adaptability of the product volume in line with the user needs. E.g. Being able to warm up heating plates separately in contact grills.
		E10	Effective use of resources during production	Reducing the amount of resources used during production. *E.g.* The lower handle of the contact grill can be designed to serve as front support leg.

APPENDIX B – CONSENT FORM FOR THE PARTICIPANTS OF THE WORKSHOP 1

Consent Form for **EMULATE | KITCHEN workshop**

Creative Sustainability Space, Aalto Arabia Campus, Ground Floor, Hämeentie 135 C, 00560 Helsinki on 29/04/2016

Researcher: Yekta Bakırlıoğlu, PhD Candidate, Middle East Technical University, Ankara, Aalto University, Helsinki

I am a PhD candidate in METU Department of Industrial Design, and I am currently visiting Aalto School of Art, Design and Architecture as a visiting researcher for the Spring semester of 2015-16 academic year. The workshop you are attending right now is a part of my PhD studies that aim to explore potentials of Open Design approach for Sustainability.

The workshop will take around 6 hours, including a focus group session in the end. The workshop session will be audio and video recorded, and photographs will be taken. The raw data as a whole will not be shared with any third parties under any circumstances, and all the physical outcomes and digital data accumulated throughout the workshop will only be used for academic and non-profit purposes. Your name may be used for giving you credit and protect your rights on your work in future publications.

By signing this consent form, you will be agreeing that your name, the images of your work and the comments you make may be used in my PhD thesis and other publications.

This does not waive your legal rights or release the researcher and/or involved institution(s) from their legal and professional responsibilities. You are free to withdraw from the study at any time, or change the conditions of your consent. If you have any further concerns related to the workshop process and outcomes, and their use, please contact:

Yekta Bakırlıoğlu, PhD Candidate
Department of Industrial Design,
Faculty of Architecture, Middle East Technical University
Phone: +90 312 210 7033
e-mail: yekta@metu.edu.tr

Participant’s name and signature	Researcher’s name and signature
Date	Date

APPENDIX C – PRINT-READY CONSIDERATION CARDS FOR WORKSHOP 1

Wine bottles, beakers, jars, bins, and many more are easy-to-acquire, standardized, and come in different sizes and materials. Utilize them instead of producing it themselves	**USING READILY AVAILABLE PARTS**	For the parts you design, try to define a common assembly detail, that can be used in other parts as well. That way, different open parts can come together for different practices	**STANDARDIZING ASSEMBLY DETAILS**
Splashes, overflows, and other accidents dirties many parts and the kitchen environment. Develop design solutions to prevent such accidents and minimize the need for maintenance.	**MINIMIZING NEED FOR MAINTENANCE**	Your part designs and the materials they are made out of should be easy-to-clean - or at least cleanable. Surfaces of parts need to be easily cleared of food remnants to be used again and again	**CLEANABLE SURFACES**
How do you understand it is time to clean parts? Do you clean it every time you use it, or when it gets really dirty? If you need feedback on maintenance need, design feedback mechanisms.	**FEEDBACK ON MAINTENANCE NEED**	The applaince is not working, but what is the problem? Is there any way to understand the problem in your design? Making the breakdown reason visible is important, design feedback mechanisms.	**FEEDBACK ON BREAKDOWN REASONS**
For repair, upgrading, or reusing parts, the appliance needs to be disassembled. Consider how disassembly can be carried out easily, adapt your part design accordingly.	**EASE OF DISASSEMBLY**	Everybody has different needs and preferences while performing kitchen practices. Discuss how your design can respond to them and point out how your design can adapt to them	**RESPONDING TO NEEDS & PREFERENCES**
You may need to take some parts apart to be able to clean them, or keep electical parts away from water. If so, how will you disassemble those parts?	**DISASSEMBLY FOR MAINTENANCE**	Motors and heating elements are used over and over again in different appliances. Is there a way to decrease their number in the kitchen? If so, how should they be designed?	**ELIMINATING DUPLICATE PARTS**

Figure 116. Print ready sustainability consideration cards for Workshop 1

APPENDIX D – CONSENT FORM FOR THE PARTICIPANTS OF THE WORKSHOP 2 (IN TURKISH)

İzin Formu: **Açık Tasarım: Mutfak Çalıştayı**

ODTÜ Mimarlık Fakültesi, Ankara, 22/09/2016

Çalıştay Ekibi:

Yekta Bakırlıoğlu / ODTÜ EÜTB, Arş. Gör. / Sustain!DRL, Araştırmacı

Senem Turhan / Sustain!DRL, Uzman Araştırmacı

Dilruba Oğur / ODTÜ EÜTB, Arş. Gör. / Sustain!DRL, Araştırmacı

Bu çalıştay sürdürülebilirlik için açık tasarım yaklaşımının potansiyellerinin anlaşılmasını hedefleyen ve Yekta Bakırlıoğlu tarafından Orta Doğu Teknik Üniversitesi Endüstri Ürünleri Tasarımı Bölümü'nde yürütülen doktora tezi kapsamında yapılmaktadır.

Çalıştay, sonunda yürütülecek odak grubu çalışması ile birlikte yaklaşık olarak 4 saat sürecektir. Çalıştay sırasında fotoğraf makinesi, video ve ses kayıt cihazı kullanılacaktır. Çalıştay sürecinde elde edilen tüm fiziksel çıktılar ve dijital veriler sadece akademik amaçlarla ve kar amacı gütmeyen çalışmalarda kullanılacaktır. Bir bütün olarak ham veri hiçbir koşulda herhangi bir üçüncü şahısla paylaşılmayacaktır. İsminiz, çalışma çıktılarındaki haklarınızı korumak için gelecek yayınlarda kullanılabilir.

Bu izin formunu imzalayarak isminizin, çalıştay çıktılarının görsellerinin ve yaptığınız yorumların tez çalışmalarında ve diğer yayınlarda kullanılacağını onaylamış oluyorsunuz.

Bu formu imzalamış olmanız yasal haklarınızdan vazgeçtiğiniz ya da araştırmacıların ve ilgili kuruluşun yasal ve profesyonel sorumluluklarından feragat ettiği anlamına gelmemektedir. Çalıştay sürecinin başlangıcında veya herhangi bir aşamasında gerekçe belirtmeksizin çalıştaydan ayrılmayı ya da izin koşullarının değiştirilmesini talep edebilirsiniz. Çalıştay süreci, çıktıları ve bu çıktıların kullanımı ile ilgili sorularınız varsa araştırmacıyla iletişime geçebilirsiniz:

Yekta Bakırlıoğlu,
Endüstri Ürünleri Tasarımı Bölümü, Mimarlık Fakültesi, ODTÜ
Tel: +90 312 210 7033
e-Posta: yekta@metu.edu.tr

Katılımcının adı soyadı	Araştırmacı adı soyadı
22 / 09 / 2016	22 / 09 / 2016

APPENDIX E – PRINT-READY CONSIDERATION CARDS FOR WORKSHOP 2

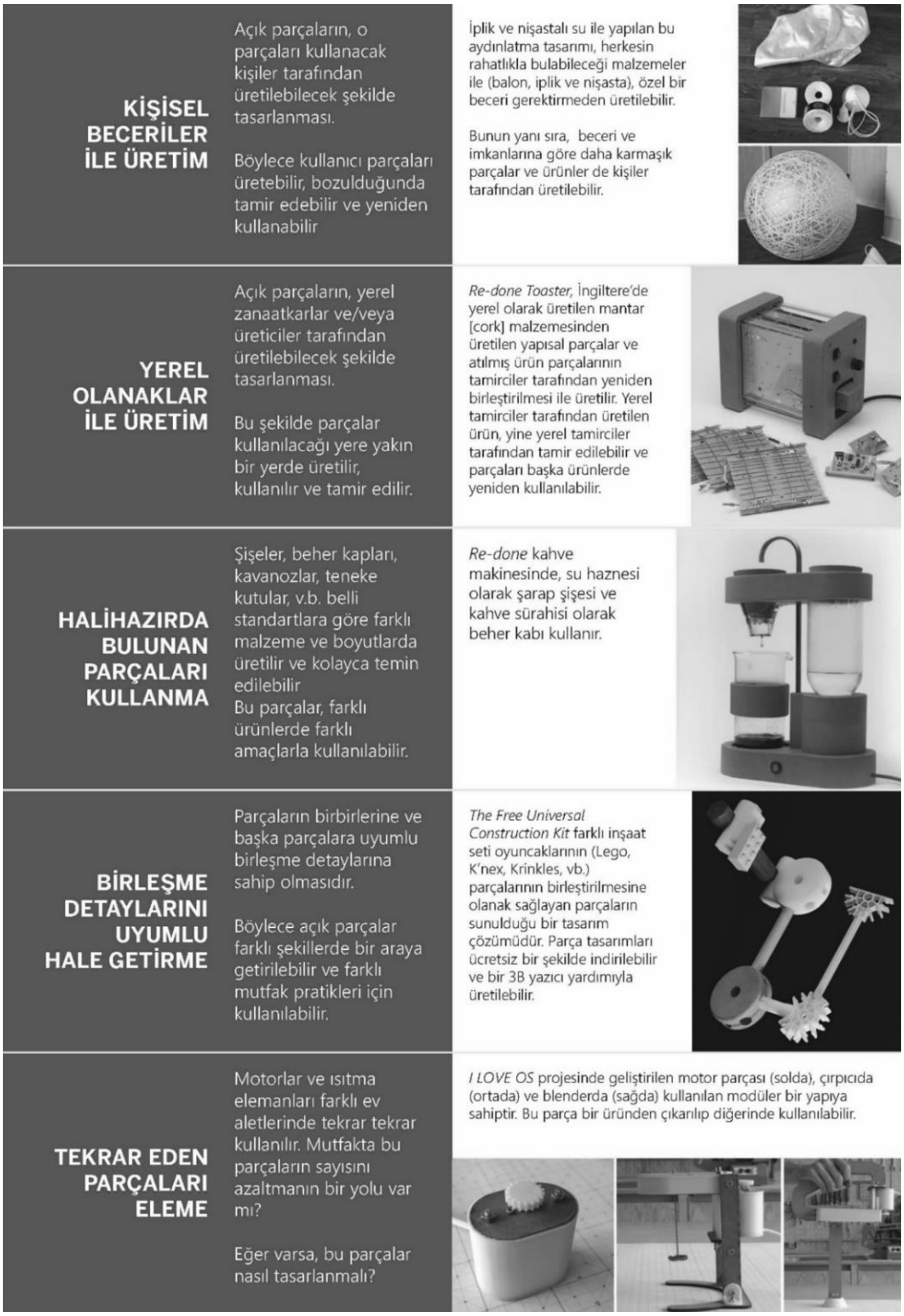


Figure 117. Print ready sustainability consideration cards for Workshop 2 – Part 1 (in Turkish).

Figure 118. Print ready sustainability consideration cards for Workshop 2 – Part 2 (in Turkish).

Figure 119. Print ready sustainability consideration cards for Workshop 2 – Part 3 (in Turkish).

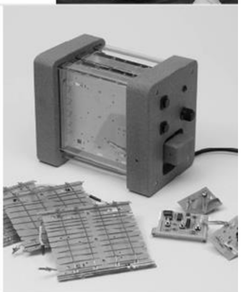
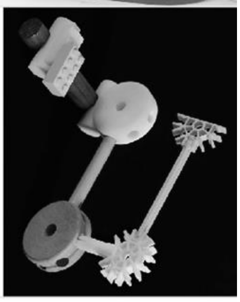
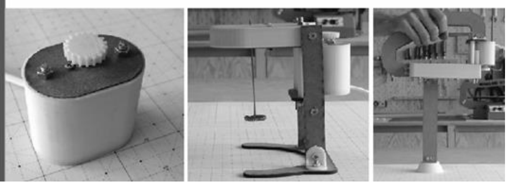
INDIVIDUAL SKILLS FOR PRODUCTION	Designing open parts in a way that users of them can produce them. Consequently, the user can produce the parts, repair them when broken and reuse them	This lighting design, made with yarn and starchy water, can be produced with the materials that everyone can easily find (i.e. balloon, thread and starch) without any specific skill. In addition to this, more complex parts and products can be produced by the people according to their skills and possibilities.	 
LOCAL SKILLS FOR PRODUCTION	Designing open parts in a way that local craftsmen and/or other local producers can produce them. Consequently, the part can be produced and repaired when broken, closer to where they will be used.	*Re-done Toaster* is produced by assembling structural parts produced out of locally produced cork material and discarded product parts by repairers. The product produced by the local repairers can also be repaired by the local repairers and the parts can be reused in other products.	
USING READILY AVAILABLE PARTS	Wine bottles, beakers, jars, bins, and many more are easy-to-acquire, standardized, and come in different sizes and materials. Utilize them instead of producing it themselves	A wine bottle is used as a water reservoir and a beaker is used as a coffee mug for the *Re-done Coffee Machine.*	
STANDARDIZING ASSEMBLY DETAILS	For the parts you design, try to define a common assembly detail, that can be used in other parts as well. That way, different open parts can come together for different practices	*The Free Universal Construction Kit* is a design solution in which parts of different construction set toys (Lego, K'nex, Krinkles, etc.) are combined. Parts designs can be downloaded for free and produced with the help of a 3D printer.	
ELIMINATING DUPLICATE PARTS	Motors and heating elements are used over and over again in different appliances. Is there a way to decrease their number in the kitchen? If so, how should they be designed?	A modular structure is used on the engine part (left), beater (center) and blender (right) developed in the *I LOVE OS project.* The motor part can be removed from one product and used on the other.	

Figure 120. Print ready sustainability consideration cards for Workshop 2 – Part 1 (in English)

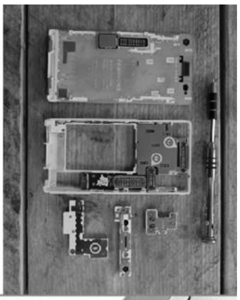
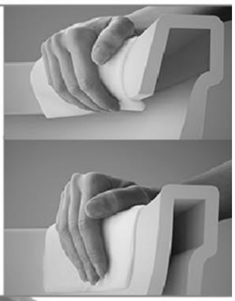
EASE OF DISASSEMBLY	For repair, upgrading, or reusing parts, the appliance needs to be disassembled. Consider how disassembly can be carried out easily, adapt your part design accordingly.	*The Fairphone 2* consists of 5 main parts joined together using a single type of screw and the screw locations are where the users can see. Anyone can disassemble this phone into parts using a single screwdriver.	
MINIMIZING NEED FOR MAINTENANCE	Splashes, overflows, and other accidents dirties many parts and the kitchen environment. Develop design solutions to prevent such accidents and minimize the need for maintenance.	The round plastic parts found in the mixer apparatus prevent the mixed materials reaching mechanical / electric parts and splashing out.	
CLEANABLE SURFACES	Your part designs and the materials they are made out of should be easy-to-clean - or at least cleanable. Surfaces of parts need to be easily cleared of food remnants to be used again and again	In the *RimX* toilet bowl design, surfaces that are difficult or impossible to clean have been eliminated. In this way, surfaces that must be hygienic can be reached and these surfaces can be completely cleaned.	
FEEDBACK ON MAINTENANCE NEED	How do you understand it is time to clean parts? Do you clean it every time you use it, or when it gets really dirty? If you need feedback on maintenance need, design feedback mechanisms.	Since *Arnica Bora vacuum cleaner*'s filter reservoir is transparent, it is clear when the filter needs to be cleaned and required maintenance can be done in a timelier manner.	
DISASSEMBLY FOR MAINTENANCE	You may need to take some parts apart to be able to clean them, or keep electical parts away from water. If so, how will you disassemble those parts?	In the *Transparent Kettle project*, the heater and other electronic components can be completely separated from the water reservoir, so the water reservoir can be cleaned easily.	

Figure 121. Print ready sustainability consideration cards for Workshop 2 – Part 2 (in English)

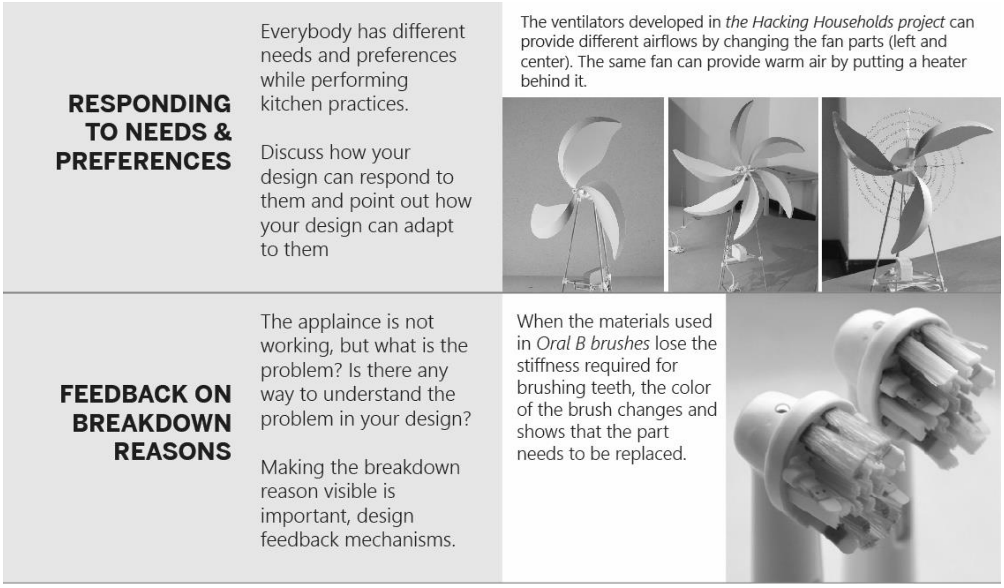


Figure 122. Print ready sustainability consideration cards for Workshop 2 – Part 3 (in English)

APPENDIX F – CALL FOR PARTICIPANTS TO WORKSHOP 1

Figure 123. Poster for Workshop 1.

APPENDIX G – POWERPOINT PRESENTATION USED IN WORKSHOP 1

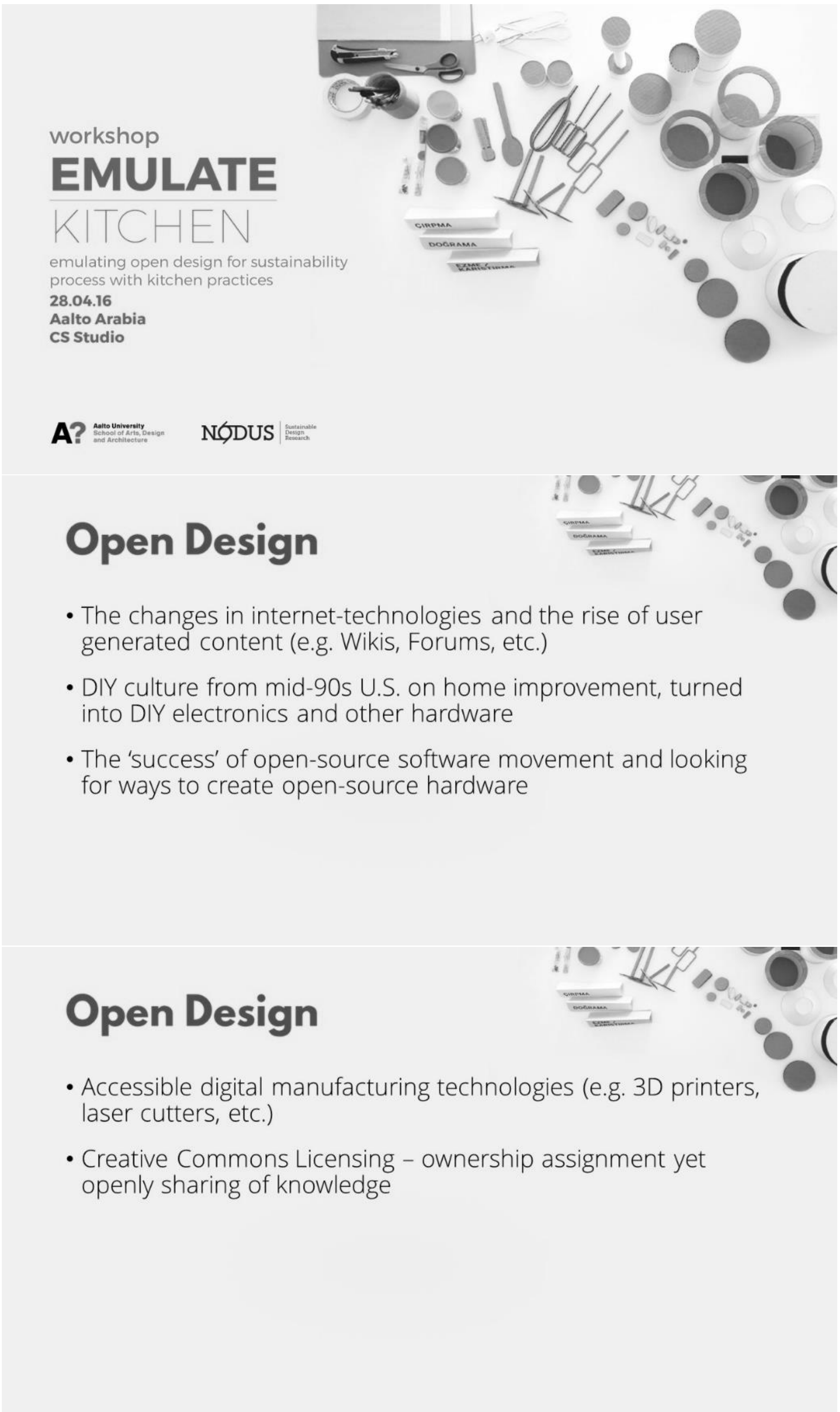


Figure 124. PowerPoint Presentation Used in Workshop 1.

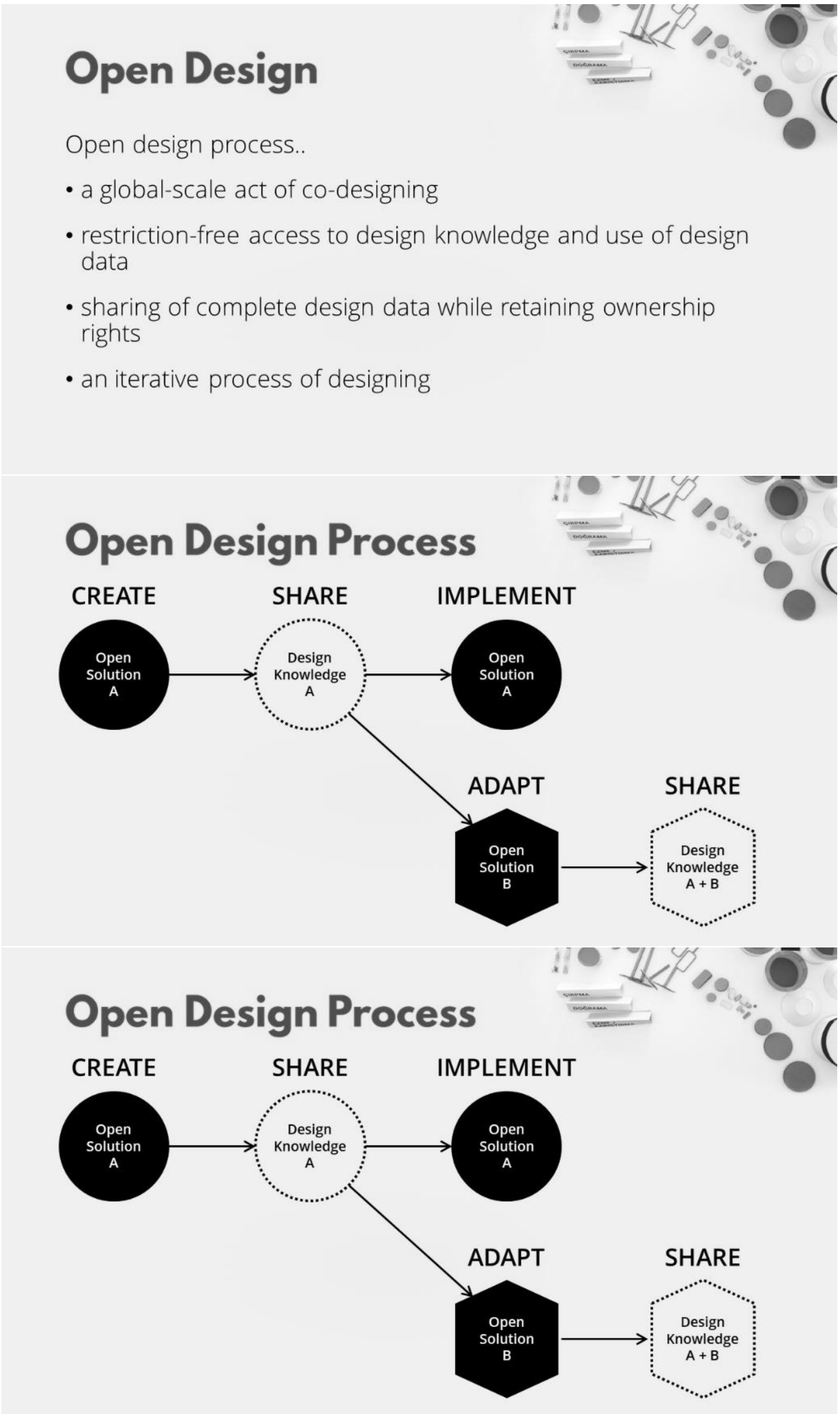


Figure 125. PowerPoint Presentation Used in Workshop 1 – Part 2.

Figure 126. PowerPoint Presentation Used in Workshop 1 – Part 3.

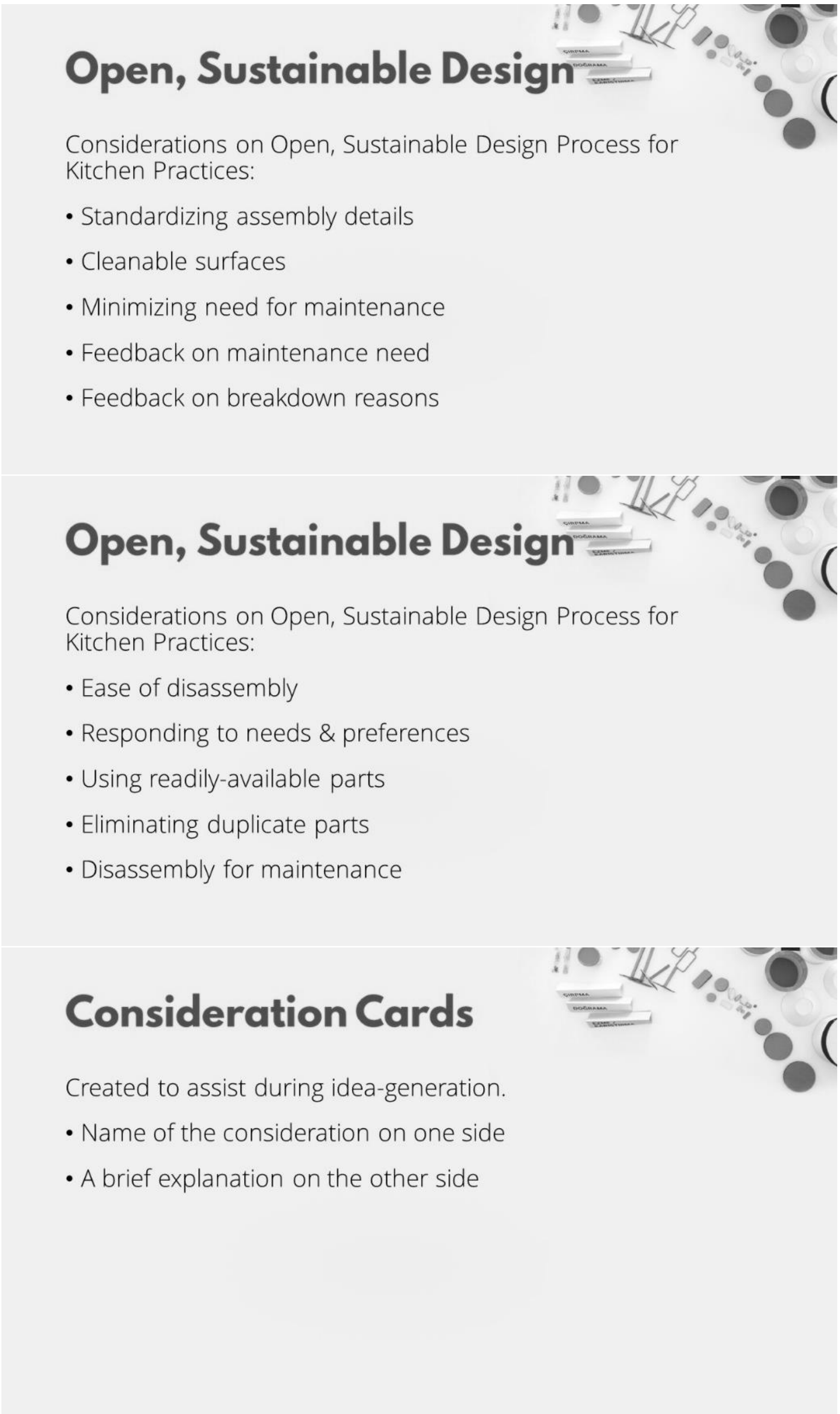


Figure 127. PowerPoint Presentation Used in Workshop 1 – Part 4.

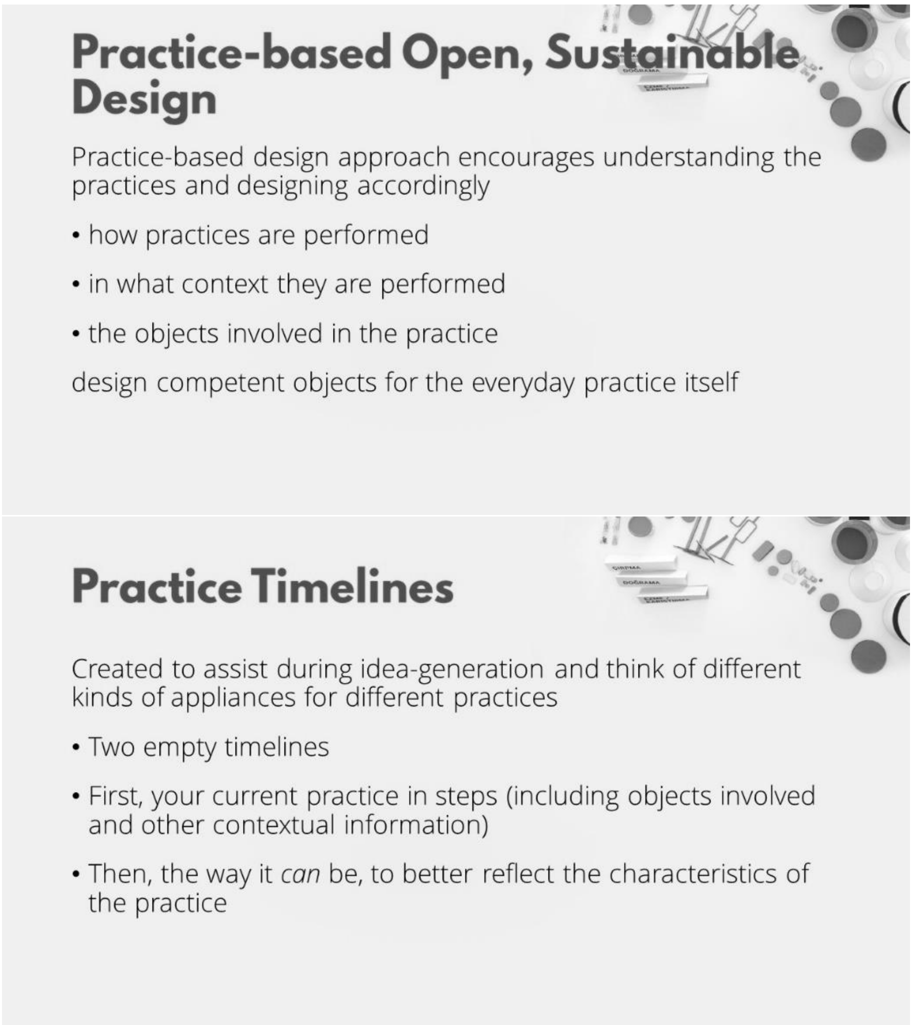


Figure 128. PowerPoint Presentation Used in Workshop 1 – Part 5.

APPENDIX H – LIST OF WORKSHOP PARTICIPANTS

Table 28. List of participants in both design workshops

Participants of Workshop 1: Iterating Open Solutions for the Same Practice		
Group 1	Tianshi Shen	PhD Candidate / Design for Sustainability
	Anonymous Participant	MA in Dept. of Arts / Design History
Group 2	Lilli Mäkelä	MA in Creative Sustainability Programme
	Outi Mustonen	MA in Fashion and Collection Design Programme
Group 3	Emma Berg	MA in Creative Sustainability Programme
	Maria Mercer	MA in Creative Sustainability Programme

Participants of Workshop 2: Iterating Open Solutions for Different Practices		
Group 1	Serenay Tosun	B.ID. 4^{th} year student
	Dilan Donat	B.ID. 4^{th} year student
	Lilyana Yazıroğlu	B.ID. 4^{th} year student
Group 2	Özge Özkök	B.ID. 4^{th} year student
	Belis Su Alper	B.ID. 4^{th} year student
	Esra Kıygın	B.ID. 4^{th} year student
Group 3	Seda Büyükvural	B.ID. 3^{rd} year student
	Elif İdemen	M.Sc. in Industrial Design, PhD Cand. In Management
	Özlem Duyan	B.ID. 3^{rd} year student
Group 4	Nesibe Kaya	B.ID. 3^{rd} year student
	Oğuz Boz	B.ID. 3^{rd} year student
	Ezgi Çakır	M.Sc. Student in Industrial Design

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Bakırlıoğlu, Yekta

Nationality: Turkish

Date and Place of Birth: 22 November 1987, Akhisar, Manisa

email: yektab@gmail.com

EDUCATION

Degree	Institutions	Year of Graduation
M.Sc.	METU Department of Industrial Design	2012
B.Sc.	METU Department of Industrial Design	2010

ACADEMIC EXPERIENCE

Year	Place	Enrollment
2013 – 2017	Sustain! Design Research Lab, METU Department of Industrial Design. sustain.id.metu.edu.tr.	Researcher
2011- 2017	METU Department of Industrial Design	Research Assistant
2016 – 2017	“Understanding the Impact of ‘Path to Sustained Usage’ Model in Product Design Process” Research Project funded by TÜBİTAK. Conducted by: Armağan Kuru & Yekta Bakırlıoğlu.	Researcher
Jan 2016 - July 2016	Aalto University, School of Art and Design, NODUS Sustainable Design Research Group.	Visiting Researcher
2014 - 2015	“The Relationship between Design and Time-based Narrative Presentations” Research Project. Conducted by: Dalsu Özgen Koçyıldırım.	Researcher

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

Doğan, Ç., Turhan, S., & Bakırlıoğlu, Y. (2016). Evolving Paths: Undergraduate Design Education through Graduate and Generative Research with Particular Focus on Sustainability. *The Design Journal, 19* (4), 587-606.

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Bakırlıoğlu, Y., (2016). Açık Tasarım için Tasarım yoluyla Araşırma: Mufak Pratikleri üzerine Bir Çalıştay. [Research through Designing for Open Design: A Workshop on Kitchen Practices]. *UTAK 2016 Proceedings, September 21-23, 2016. (in Turkish), Middle East Technical University,* 189-204.

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Özgen Koçyıldırım, D., Coşkun, A., & Bakırlıoğlu, Y. (2015). Time-Based Visual Narratives for Design Education. *LearnxDesign: The 3rd International Conference for Design Education Researchers and PreK-16 Design Educators, 28-10 June 2015, Chicago, USA.*

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Yetiş, E. Ö. & Bakırlıoğlu, Y. (2015). Heterotopia and Participatory Design: The Case of Occupying On-Campus Starbucks. *4T 2015: Design in Times of Turmoil: Displacement, Replacement, Emplacement Conference, 14- 15 May 2015, İzmir, Turkey.* (to be published).

Boğazpınar, H., Bakırlıoğlu, Y., Kuru, A., & Erbuğ, Ç. (2014). Path to Sustained Usage: A Model for Long Term Experience in Technological Products. *9th Design and Emotion 2014 Proceedings: The Colors of Care, 6-10 October, Universidad de los Andes, Bogota, Colombia,* 667-679.

Bakırlıoğlu, Y., Doğan, Ç., & Turhan, S. (2014). Elektrikli Ev Aletleri Sektöründe Sürdürülebilirlik İçin Tasarım: Kaynakların Verimli Kullanımı ve Ürün Bakımı ve Onarımı Konularında Tasarımcı ve Üretici Yaklaşımlarının ve Farkındalığının Anlaşılması. [Design for Sustainability in Electrical Household Appliances: Understanding Approaches and Awareness of Designers and Manufacturers on Effective Use of Resources, Product Maintenance and Repair.]. *UTAK 2014 Proceedings: Education, Research, Profession and Social Responsibility; September 10-12, 2014. Middle East Technical University, Ankara, Turkey,* 133-146.

Özgen Koçyıldırım, D., Coşkun, A., & Bakırlıoğlu, Y. (2014). Endüstri Ürünleri Tasarımı Eğitiminde Zaman Temelli Görsel Anlatımın Algısal Etkileri. [Perceptual Effects of Time-based Visual Narrative in Industrial Design Education]. *UTAK 2014 Proceedings: Education, Research, Profession and Social Responsibility; September 10-12, 2014. Middle East Technical University, Ankara, Turkey,* 301-312.

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Bakırlıoğlu, Y., & Doğan, Ç. (2012). Biomimicry Sketch Analysis: A Generative Tool for Sustainability in Product Design Education. *Sustainable Innovation 2012, Resource Efficiency, Innovation and Lifestyles Conference Proceedings, 29-30 October, Bonn, Germany,* 6-15. *Best Paper Award*.