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PRODUCT REPURPOSING: TYPOLOGY AND DESIGN CONSIDERATIONS

Reposição de produto: considerações de tipologia e projeto

Mohammed I. M. Ali[1], Mian Mobeen Shaukat[2], N. Merah[3], S. Pashah[4]
[1 2 3 4] Department of Mechanical Engineering, KFUPM, Dhahran Saudi Arabia
E-mail: mohammed-07@hotmail.com; mshaukat@kfupm.edu.sa;
nesar@kfupm.edu.sa; sulaman@kfupm.edu.sa

ABSTRACT

Product repurposing is a self-serving, self-rewarding sustainable behavior. It has been around ever since people began to create and acquire objects. However, very few studies have been conducted on product repurposing, and there is no typology of it in the literature. The aim of this study is to systematically classify the types of product repurposing and provide illustrating examples. Then based upon the developed typology, the corresponding design considerations that would enable, facilitate, and encourage users to perform this practice will be identified and mapped against the product repurposing types. To reveal the underlying types of product repurposing, a comprehensive analysis of a myriad of successful Do-It-Yourself (DIY) repurposing projects has been conducted. For categorization, two dimensions were considered: the modification to the product form (or the lack of it) and the approach to product transformation in terms of integration with other products or components (or the lack of it). The crossing of those two dimensions (Modification and Combination) produced four distinct types of product repurposing: Unmodified-Solo, Modified-Solo, Modified-Combined, and Unmodified-Combined. The repurpose-enabling design considerations were found to be, chiefly, Material, Affordances, Modularity and Ease of Disassembly, and User-product Attachment. These considerations were then mapped against the four repurposing types, and a conceptual framework was produced. It is important to note that this study is limited to End-of-Life individual scale repurposing and to Design for Open-ended Repurposing strategy. The presented typology is exhaustive and the first of its kind. The typology, coupled with the identified design considerations, would greatly assist designers in developing repurpose-enabling products.

Keywords: Product Repurposing; Typology; Design Considerations; Conceptual Framework; Sustainable Design; Circular Economy.

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REPOSIÇÃO DE PRODUTO: CONSIDERAÇÕES DE TIPOLOGIA E PROJETO

Product repurposing: typology and design considerations

Mohammed I. M. Ali[1], Mian Mobeen Shaukat[2], N. Merah[3], S. Pashah[4]
[1 2 3 4] Department of Mechanical Engineering, KFUPM, Dhahran Saudi Arabia
E-mail: mohammed-07@hotmail.com; mshaukat@kfupm.edu.sa;
nesar@kfupm.edu.sa; sulaman@kfupm.edu.sa

RESUMO

O reaproveitamento de produtos é um comportamento sustentável que serve a si próprio e que recompensa a si próprio. Existe desde que as pessoas começaram a criar e adquirir objetos. No entanto, muito poucos estudos foram realizados sobre o reaproveitamento de produtos, e não há tipologia na literatura. O objetivo deste estudo é classificar sistematicamente os tipos de redirecionamento de produtos e fornecer exemplos ilustrativos. Em seguida, com base na tipologia desenvolvida, as considerações de design correspondentes que permitiriam, facilitariam e encorajariam os usuários a executar essa prática serão identificadas e mapeadas em relação aos tipos de redirecionamento do produto. Para revelar os tipos subjacentes de reaproveitamento de produtos, foi realizada uma análise abrangente de uma miríade de projetos bem-sucedidos de reaproveitamento faça você mesmo (DIY). Para a categorização, duas dimensões foram consideradas: a modificação da forma do produto (ou a falta dela) e a abordagem da transformação do produto em termos de integração com outros produtos ou componentes (ou a falta dela). O cruzamento dessas duas dimensões (Modificação e Combinação) produziu quatro tipos distintos de reaproveitamento de produtos: Solo Não Modificado, Solo Modificado, Solo Modificado, Combinado Modificado e Combinado Não Modificado. As considerações de projeto que possibilitam o reaproveitamento foram, principalmente, Material, Preços, Modularidade e Facilidade de Desmontagem e Anexo ao Produto do Usuário. Essas considerações foram mapeadas contra os quatro tipos de redirecionamento e uma estrutura conceitual foi produzida. É importante observar que este estudo se limita ao reaproveitamento em escala individual no final da vida útil e à estratégia de Design para reaproveitamento por tempo indeterminado. A tipologia apresentada é exaustiva e a primeira desse tipo. A tipologia, juntamente com as considerações de design identificadas, ajudaria bastante os projetistas no desenvolvimento de produtos que permitam reutilização.

Palavras-chave: Redirecionamento de produtos; Tipologia; Considerações de design; Estrutura conceitual; Design sustentável; Economia circular.

INTRODUCTION

According to the World Bank, by 2100, the amount of solid waste generated globally is expected to triple. This is attributed to "the growing global population, consumerism and the linear approach to industrialization" (Minelgaitė & Liobikienė, 2019). One approach to reducing resource consumption is slowing the resource loops (i.e., slowing the throughputs) by prolonging products lifespans or designing products for multiple cycles. This approach is one of three existing Design for Sustainability approaches that, arguably, support Circular Economy (CE)–which is gaining attention as the alternative to Linear Economy (i.e., the traditional take-make-dispose model) (Moreno, De los Rios, Rowe, & Charnley, 2016; Ashby, 2014; Haupt & Hellweg, 2019).

There are four End-of-Life (EoL) strategies frequently mentioned in the literature: reusing, remanufacturing, recycling and disposal. Eliminating the final disposal is an essential principle of CE, and the other three EoL strategies are important product value retention processes (Haupt & Hellweg, 2019).

"Recycling is often considered the environmentally soundest solution" (Millrath & Themelis, 2003), but it has its disadvantages. Recycling often requires water and energy for material reprocessing, and it often degrades the constitution of the material (Lewis, 2018). It also requires great amounts of energy for transportation, processing, and manufacturing. On the other hand, reuse and remanufacturing extend the product lifespan with no material reincarnation involved, thus result in sustainable benefits. However, remanufacturing and direct reuse are not viable options when the product becomes functionally obsolete. In such case, the indirect reuse EoL strategy (repurposing) becomes pertinent (Bauer, Mandil, Naveaux, & Zwolinski, 2016).

Although, the sustainable gains of repurposing are obvious and could easily be obtained, repurposing is still a marginal practice in terms of research focus and user behavior. Few studies were conducted on repurposing (and upcycling). They, mostly, highlighted the importance of the practice, demonstrated the need for it, or discussed the reasons that encourage it. In this study we will develop a systematic, exhaustive typology of repurposing, then identify the design considerations that would enable, facilitate, and encourage users to repurpose at the product EoL, and finally a conceptual framework will be developed by mapping the design considerations against the repurposing types.

1. LITERATURE REVIEW

1.1 Product Repurposing

As defined by Aguirre, "repurposing is creating a new or a second life for an existent product by making some transformations to it" (Aguirre, 2010). It is a self-serving, self-rewarding sustainable behavior. It has been around ever since people began to create and acquire objects. It is perhaps the oldest sustainable EoL strategy. Archeological discoveries show that very early in life, people started to repurpose the items they owned, by the end of their lives. At an excavation site in hungry, the archeologist Maikel Kuijpers discovered spindle whorls made from broken pot fragments that date back to the Bronze Age. However, he argues that this practice was not driven by environmental consciousness, but rather happened out of necessity (Kuijpers, 2019). Nonetheless, in modern days, people repurpose products for different reasons. Do-it-yourself (DIY) websites and online forums are daily provided with new repurposing projects and ideas.

Repurposing saves energy and water, as it does not involve material reprocessing nor does it require transportation; individuals can repurpose products at their places. As a process, repurposing results in less pollution, requires less resources, and costs less compared to recycling. It also saves the user's money and it saves resources that would have been demanded for recycling, remanufacturing, or transportation to landfills. Moreover, repurposing alleviates the burden of devoting space to landfills and managing them (Aguirre, 2010).

It is important to highlight that one special case of repurposing is upcycling, "the practice of taking something that is disposable and transforming it into something of greater value" (Lewis, 2018). The oxford dictionary defines the word "upcycle" in a similar way "Reuse (discarded objects or material) in such a way as to

create a product of higher quality or value than the original" ("Upcycle | Definition of Upcycle by Merriam-Webster," 2019). These two definitions are in agreement with the definition provided by Braungart and McDonough, who coined the term "upcycle", in their book 'Cradle to Cradle: Remaking the Way We Make Things' (McDonough & Braungart, 2002); in this definition the outcome of upcycling is of a higher value. However, not every repurposing process is necessarily value-adding.

Judging whether or not the new product is of a higher value than the original is difficult, subjective, and debatable. That is why upcycling and repurposing are frequently used in the wrong context. Our focus in this study will be on repurposing from a design perspective that focuses on the product form, and the approach to product transformation without debating the value of the outcome versus the value of the original product.

There are many reasons that drive people to repurpose. Based on our review of the literature and the analysis of a myriad of DIY repurposing projects, we found that those reasons could be summarized as follows: necessity, creativity, financial, emotional, and environmental reasons (Aguirre, 2010; Sung, Cooper, & Kettley, 2014; Bridgens et al., 2018). Nonetheless, these reasons greatly overlap. For instance, being emotionally attached to a product of a sentimental value will spark user's creativity to transform it into something they would keep interacting with. A perfect example of this is the "Memory Quilt", which is made out of the user's old T-shirts (Figure 1). Needles to say that being environmentally conscious could overlap with all the other reasons.

Figure 1. Old T-shirts repurposed into a "Memory Quilt"
Image used with permission

Fonte: https://www.instructables.com/id/DIY-Custom-T-Shirt-Quilt-Top-Variable-Style-With-1/

Another example of Modified-Solo repurposing is transforming a glass jar into a sewing kit container with a pincushion (Figure 6). The addition of the pincushion changed the jar's form and it is now used for a slightly different function, which is storing and holding sewing items–instead of containing food.

Figure 6. A glass jar repurposed into a sewing kit container with a pincushion
Image used with permission

Fonte: https://www.instructables.com/id/Sewing-Kit-in-a-Jar-1/

Repurposing a shopping cart into a chair is another excellent example of Modified-Solo repurposing (Figure 7). In this example the shopping cart form was changed completely and its new function is entirely different.

Figure 7. A shopping cart Repurposed into a chair
Image used with permission

Fonte: https://www.instructables.com/id/REMIX-Shopping-Cart-Chairs-are-Awesome/

It is important to understand that thinking of ways to transform, and transforming, a product into a new one of the same or similar function requires a little cognitive workload from the user and may happen over a short period of time, whereas repurposing a product to meet a significantly different function requires overcoming functional fixedness, which is defined as “a cognitive bias that describes how previous knowledge of a tool's function can negatively impact the use of this tool in novel contexts”. Overcoming fixation would happen over a

long period of time (i.e., needs more opportunity for incubation and exposure to external stimuli) (Munoz-Rubke, Olson, Will, & James, 2018).

Sometimes, the form modification involves nothing but changing the product colors. And the reason behind it is either:

a. Making the repurposed product visually apt for the new context, e.g., coloring old tires before using them as planters and flower beds (Figure 8)

Figure 8. Old tires repurposed into planters and flowerbeds
Image used with permission

Fonte: https://commons.wikimedia.org/wiki/File:Diy_for_old_tires.jpg

b. Eliminating the confusion when the repurposed product is used in a completely novel context. For instance, perfectly positioning a nonworking microwave at the doorstep may not be an enough sign for the carrier to put the mails in it. Therefore, adding a decorative design, and perhaps some wording is a wise idea (Figure 9).

Figure 9. A broken microwave repurposed into a mailbox
Images used and reproduced with permission

Fonte: https://www.instructables.com/id/Convert-a-Broken-Microwave-into-a-Mailbox/

1.2 Modified-combined

In this repurposing type, objects of the same form and function, or of an entirely different forms and functions are modified and combined to create a new product. This is usually the approach to repurposing used textiles. Parts of obsolete textiles are sewed together, or to a non-textile product, to make a new product (e.g., T-shirt Quilt, Figure 1). However, it has also been observed that this repurposing type is not exclusive to textile products.

For instance, creating an ice-based cooler by combining a modified car fan and a container is Modified-Combined repurposing (Figure 10). The forms of the container and the car fan were modified before combining them. All you need to do to get cool air form the new device is to put iceboxes inside the container and connect the fan to an electricity source.

Figure 10. A small car fan and a plastic box repurposed into an ice-based cooler
Image used with permission

Fonte: https://www.instructables.com/id/Simple-Cheap-Air-Conditioner/

Another example of modified-combined repurposing is transforming a milk crate and an old scooter into a cart (Figure 11).

Figure 11. An old mild crate and a scooter repurposed into a cart
Images used with permission

Fonte: https://www.instructables.com/id/Build-a-Milk-Crate-Cart/

Also, users sometimes combine several modified units of the same product to create a new product of a new purpose. An example of this, is repurposing old coat hangers into a coat rack (Figure 12).

Figure 12. Old coat hangers repurposed into coat rack
Images used with permission

Fonte: https://www.instructables.com/id/repurposed-coat-hanger-rack/

Also, we observed that old kitchen utensils (spoons, forks, rolling pins, et cetera) are often modified and combined to create some useful products.

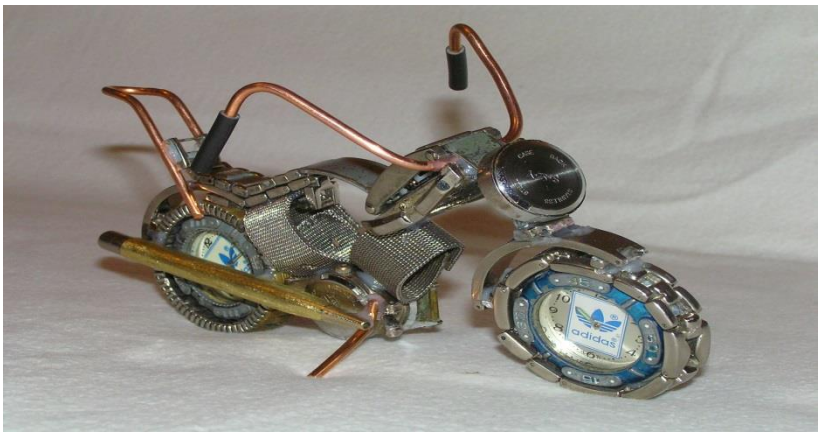
In some cases, the outcome of repurposing (the new product) has no purpose other than to entertain viewers or convey a certain message in an artistic way. This kind of artistic work is referred to as junk art (a term that was coined in 1950s to refer to artworks made from discarded machinery, rags, scrap plastic or metal, or other kinds of junk) (Razali, Rathi, Wasli, Jimel, & Abidin, 2018). Our investigation revealed that Junk Art projects are mostly Modified-Combined repurposing. One example of Junk Art is repurposing scrap metal into a dragonfly desk model (Figure 13).

Figure 13. A dragonfly made from scrap metal
Image used with permission

Fonte: https://cdn.instructables.com/ORIG/F5E/T33J/IWQUZVXV/F5ET33JIWQUZVXV.jpg

Another interesting example is repurposing old watches and an old metal pen into a motorcycle desk model (Figure 14).

Figure 14. Old watches and an old metal pen repurposed into a motorcycle desk model
Image used with permission



Fonte: https://www.instructables.com/id/Recycle-Old-Watches/

1.3 Unmodified-combined

In this repurposing type, two units or more of the same product (without changing their forms) are combined and transformed into a new product. It is important to note that we do not consider joining products by sewing, gluing, zipping, clipping, or welding as a modification to their forms.

Technically obsolete products, such as floppy disks and CDs, are often combined to create new products of new purposes. For instance, floppy disks could be combined to make a bills caddy (Figure 15).

Figure 15. Floppy disks Repurposed into bills caddy
Image used with permission

Fonte: https://www.instructables.com/id/Floppy-Disk-Bill-Caddy/

Another example of Unmodified-Combined repurposing is combining milk crates to create a clothes' storage (Figure 16). Although each crate is still serving the same function (containing something), the crates are combined and fixed at a specific orientation to fulfill a new purpose.

Figure 16. Milk crates repurposed into a clothes storage
Image used with permission

Fonte: https://www.instructables.com/id/milk-crate-clothing-storage/

Using the developed typology as a guide, the features and qualities that would enabled, facilitated, or encouraged each repurposing type were identified. The similar features and qualities were then clustered into one design consideration. The next section presents the identified design considerations and discusses how each consideration influences product repurposing.

2 DESIGN CONSIDERATIONS

Repurposing has the potential to change the way we think of products. Products are no longer stand-alone objects with single lives, but rather products, or assemblages of modular products, with multiple lifespans (Richardson, 2011). With such mindset, designing for repurposing becomes an intuitive design approach. Nevertheless, there are some important design aspects to consider:

1 Material
2 Affordances
3 Modularity and Ease of Disassembly
4 User-product attachment

2.1 Material

The common thread in all the investigated DIY projects was material durability. For repurposing, "it is ideal that materials are long lasting" (Aguirre, 2010). However, a rationalization of the material quality parameters, based on the component or the product lifespan, is needed. Objects of long lifespans better be of high quality, and short lifespan objects–such as packaging–better be degradable and of no environmental impact at their end of life. Objects made of degradable materials could still be repurposed if the user is well-aware of the degradation triggers and timescale (Bridgens et al., 2018) (Richardson, 2011).

Another material aspect is the amount of the material used. It sets a limit for creativity in repurposing and determines the range of potential uses; the more material used, the wider the range of repurposing possibilities.

However, there is a tension between light-weighting and design for repurposing. Designing of packages and products with just enough material to serve a specific function, reduces the amount of energy required for, and emissions from, transportation. Nevertheless, such objects are unlikely to be repurposed due to their insufficient strength. Surely, overdesigning is not the answer (Bridgens et al., 2018). Determining the amount of the material is a real design challenge when designing for repurposing. It requires a comparative Life Cycle Cost (LCC) and environmental Life Cycle Assessment (LCA).

One material aspect that is often overlooked is the quality of 'ageing gracefully'. Materials and coatings that mature in a beautiful way should be selected, to encourage open-ended repurposing (Haines-Gadd, Chapman, Lloyd, Mason, & Aliakseyeu, 2018).

2.2 Affordances

Affordances are possible ways of interacting with a product. Designers create the affordances of an object (by specifying all the properties that will afford certain uses to certain users–such as geometries and colors). The object affordances determine how it can be used. For instance, a flat surface affords resting of objects or sitting. Symmetric objects afford using their other side when one side is damaged (also two equal items could be made out of one symmetric object). And flat edges afford hanging of items. However, designers must learn from users what they desire the product to afford. That is the entanglement between, designers, products, and users (Aguirre, 2010; Srivastava & Shu, 2013; Maier & Fadel, 2009).

When designing for repurposing, DIY websites and online forums make a significantly valuable source of insight into what users want the product to afford them apart from the designer intention. Moreover, Designers can also emphasis particular affordances of a product to direct the user towards specific repurposing ideas. This will most probably help the users overcome functional fixedness (Lai & Shu, 2014; Srivastava & Shu, 2013).

2.3 Modularity and ease of disassembly

Many products are designed in a way that makes them obsolete once their weakest component fail, and they are then disposed of. In that end, a modular product would allow for deconstruction so that some components could evolve into separate products or enter a new technical cycle as components of another product (Richardson, 2011). And the appropriate product modularization would increase the possibility of repurposing.

Cost, functional independence, standardization, and ease of manufacturing are determining factors for deciding the sizes and contents of the modules. Nonetheless, to increase the possibility of repurposing, the following module characteristics should be considered: technical stability, functional upgradability, and longevity (Kimura, Kato, Tomoyuki, & Masuda, 2001).

To complement the product modularity, the product should be designed for ease of disassembly in order to facilitate repurposing. Design for repurposing, should favor mechanical connections of materials over thermal ones so that the product could be disassembled with minimal effort.

When selecting the joining manufacturing processes, any process that may compromise objects future repurposing should be avoided. This includes any process that would require particular separation tools or fixtures (Bridgens et al., 2018; Veerakamolmal & Gupta, 2000).

2.4 User-product attachment

Product attachment is "the emotional bond a consumer experiences with a durable product" (Schifferstein & Zwartkruis-Pelgrim, 2008). Without the user attachment to their product, product physical durability–or any other quality–by itself will not make the user desire to keep the product (Page, 2014a). People tend to keep products of sentimental values. And we argue that product attachment can as well encourage users to repurpose.

It has been found that nostalgia is the primary reasons people keep old products (Page, 2014a). Not surprisingly, we found that users repurpose some product for the same reason; nostalgia. Old T-shirts are transformed into what is called "The Memory Quilt" (Figure 1). The name reflects the positive emotional connection users have with the old T-shirts and the nostalgia they bring. Which in turn encouraged users to invent a new purpose for the old T-shirts in order to keep interacting with them.

Although memories are of a circumstantial nature, it may still be possible to influence the formation of users associations with their products through design. For instance, colors and patterns–especially of clothes–are a way of self-expression, and they reflect the user's personality (Page, 2014b). Allowing users to select the product colors and patterns would foster their emotional connection to the products, and thus encourage users to keep the product for longer (either as they are or for a new purpose). Moreover, products that are designed to be used within a group scenario are likely to form memories and associations of interacting with the group.

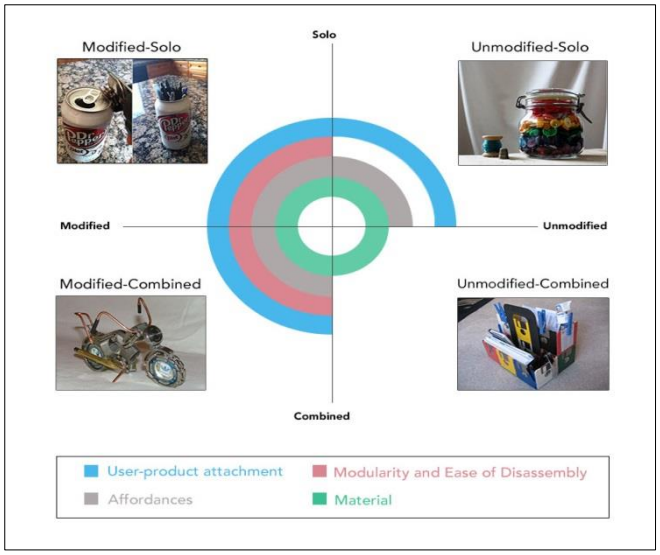
Another way to influence memories formation is through material selection. Materials that show the "general wear and tear of use" as they age are often associated with fond user memories and experiences, and they provoke user's attachment to the product (Page, 2014b).

Designers can also foster the user-product attachment by designing products that require assembly and encouraging users to assemble them with family members or friends. This would add meaning to the product and strengthen the attachment to it.

3. CONCEPTUAL FRAMEWORK

The four identified repurpose-enabling design considerations could be mapped against the four types of product repurposing to produce a Conceptual Framework (Figure 17).

Figure 17. A conceptual framework of the repurpose-enabling design considerations



As demonstrated in the first quadrant, Modularity and Ease of Disassembly plays no role in enabling or encouraging users to carry out Unmodified-Solo repurposing. That is because Unmodified-Solo repurposing require no modifications to the product form nor does it require any kind of integration with other products or components. The second and third quadrants clearly show how all the identified design considerations influence Modified-Solo and Modified-Combined repurposing types. In the fourth quadrant, however, Material is the only present design consideration. To enable and encourage open-ended Unmodified-Combined repurposing, designers should only consider materials durability and their quality of ageing gracefully.

It is important to note that although Material is the only design consideration related to Unmodified-Combined repurposing, the amount of the material used (one of three Material aspects) has no direct effect on Unmodified-Combined repurposing since no form modification is required. The same applies to Unmodified-Solo repurposing.

Affordances and User-product attachment, on the other hand, has no role in enabling, facilitating, or encouraging Unmodified-Combined repurposing. This is due to the facts that (i) the outcome of Unmodified-Combined has a completely different Affordance, and (ii) the User-product attachment is usually between the user and a product of a sentimental value, whereas Unmodified-Combined typically involves a set of technically obsolete items, containers, or kitchen utensils.

What is unique to the second and third quadrants (modification side of the conceptual framework) is Modularity and Ease of Disassembly. It is the key facilitator of form modification and thus of the two repurposing types that involve form modification (Modified-Solo and Modified-Combined repurposing).

CONCLUDING REMARKS

Through a comprehensive analysis of a myriad of successful Do-It-Yourself End-of-Life repurposing projects, the research reported in this paper has developed a systematic, exhaustive typology of product repurposing. The typology comprises four distinct repurposing types: (1) Unmodified-Solo, (2) Modified-Solo, (3) Modified-Combined, and (4) Unmodified-Combined. The developed typology was then used as a guide to determine the repurpose-enabling design considerations. And they were identified to be, chiefly, the following: (1) Material, (2) Affordances, (3) Modularity and Ease of Disassembly, and (4) User-product attachment. Finally, a conceptual framework was produced by mapping the four design considerations against the four repurposing types.

The major contribution of the paper is the development of the Product Repurposing Typology and the complementing Conceptual Framework of Open-ended Repurposing Design Considerations. The presented typology is exhaustive and the first of its kind. The typology, and the conceptual framework would greatly assist designers in developing products that would enable, facilitate, or encourage open-ended product repurposing at the end of the product useful life.

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