Summer 5-30-2017

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Alex Lobos
Rochester Institute of Technology

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Redefining Sustainability Potential in Product Design

Alex Lobos
a

aRochester Institute of Technology
+Alex.Lobos@rit.edu

Abstract: Sustainability in product design is not determined only at the creation of an object; it can be acquired over time, just like a product that was designed with sustainability in mind is misused and underappreciated. Designers need to redefine how products and systems are created, and users need to reevaluate their relationship with them by engaging in sustainable behaviors at multiple points of their lifecycle. This paper introduces a categorization of products based on their ability to solve user’s needs and to minimize environmental impact across the lifecycle. Categories range from sub and ephemeral products, which don’t even serve relevant functions, to regular, superior and catalysts products that operate with minimal environmental impact while also promoting sustainable behaviors in their users. This categorization is not intended to be a comprehensive framework for sustainable products but rather an enabler of discussion around sustainability potential which be obtained in multiple levels.

Keywords: Sustainability, Emotion, User Behavior, Industrial Design, Products

1. Introduction

As important as sustainability has become in today’s society, it suffers from continuous clashes with unregulated manufacturing processes and unclear methods for product end of life (Robert, et. al, 2002). At the heart of this issue is the extreme consumerism that is result of planned obsolescence and frequent introduction of new products with only incremental improvements over their previous versions (Spangenberg et al., 2002). Companies are in the business of selling goods and services and designers, for better or worse, have the expertise to translate needs and wants into attractive, desirable products.

In recent years, there have been a number of key sustainability approaches that resonate well with new product development. These approaches include lifecycle assessment, whole systems thinking (Clark et al., 2009) and most recently, circular economy (Ellen McArthur Foundation, 2013). The main factor that they have in common is the understanding of the lifecycle not as a linear sequence but rather as a continuous cycle where stages are all interconnected and affect each other. Circular economy, in particular, makes evident that the latter stages of a system are critical for the initial stages of subsequent ones (Andrews, 2015). If this cycle is not seen as a closed, continuous loop as it occurs in nature, there will be environmental consequences that deplete natural resources and compromise quality of life.
While sustainable design develops products with the best intentions and potential, for many product categories it is not until their actual use stage that sustainability performance and benefits begin to be evident. Sustainable products that are used in irresponsible ways no longer fit in the category and can become as negative as products that are designed without particular environmental concerns in mind. In return, products that are designed with no special attention to sustainability, can still become sustainable if they are used in responsible ways and if their lifespan is extended considerable, which in most cases offsets their environmental impact generated during manufacturing.

With this perspective in mind, a categorization of products emerges, based on their innate value as useful objects and combined with their impact on the environment and society. The categorization starts with sub products, which have no real utility in them and are developed just for a quick reaction in their users, with no other benefit that keeps them useful after a first impression. Second are ephemeral products, which provide limited opportunities for a long lifespan, either by limited functionality or quality. Third are regular products, most of which are not designed with particular sustainability benefits, but that can become sustainable if used appropriately, beyond their typical lifespan. Fourth are superior products, which are designed with their lifecycle in mind, making them more efficient to manufacture, to use, and to dispose of. Fifth are super products, which are created and operate efficiently while also promoting better behaviors in their users that have positive impacts beyond direct user-product interaction. Reassessing products from this perspective provides a new hope for many objects that could be overlooked an underappreciated by users but that in fact can provide benefits short and long term.

2. From basic utility to sustainable attachment

At their most basic level, products are "a bundle of attributes (features, functions, benefits, and uses) capable of exchange or use (AMA, 2016)." In other words, products are objects that satisfy needs or wants. This definition frames a context or goal for products but it is hardly a matter of something being simply useful or not useful. This degree of usefulness defines the value of a given product and it is critical to determine its relevance in society, and consequently, its sustainability. Product value is a perceived notion from consumers who evaluate the cost of a good or service versus its benefit. The notion of value is critical to determine the success of a given product as it will drive how important a device can be in a person’s life. Value can be measured at different levels, ranging from utility to comfort and social status (Sweeney & Soutar, 2001). But no matter what specific measure is used to determine a product’s value, the higher that it goes, the further that consumers will try to maintain the product in their possession.

Determining the value of a product can vary significantly, depending on category and consumer expectations. Products used to be measured by their form and function. This was an effective way of understanding common attributes of a product but as their relationship with users has evolved, their value structure has become more complex, too. Since the 1980’s there has been more attention given to holistic interactions with products and emotional design emerged as a way of understanding how products transcend notions of form and function. Hartmut Esslinger from Frog Design described how the concept of ‘form follows function’ had transformed into ‘form follows emotion’ (Edwards, 1999), while Donald Norman (2004) explored emotional design based on reactions caused by user interaction with products, ranging from visceral to behavioral and reflective. Jonathan Chapman (2005) proposed an integration of emotional attachment and sustainability into a model that promotes products that connect deeply with their users, leading to emotional durability and

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extended lifespans. Most recently, Pieter Desmet and Anna Pohlmeyer (2013) have discussed design’s ability not only for creating strong user emotions but also to promote positive behaviors and attitudes. Along with these angles for emotional design, a popular structure proposed by Patrick Jordan (2002) remains relevant today and is very helpful for understanding the progression of user-product interaction. At the most basic level, products need to have a function; they need to fulfill a need. Once a function has been established, products can aspire to be usable. Only when functionality and usability have been secured, then a product can provide true pleasure and enjoyment. Jordan’s progression of product interaction is simple yet extremely insightful. Products that are convenient, comfortable and reliable are more likely to provide positive experiences to their users, enabling an emotional connection.

Along with improving user interaction, emotional design has the ability to give a sustainable advantage to a product that was designed with no particular considerations for environmental impact. The advantage comes from users that connect deeply with their products and use them beyond their expected lifespan. Users are also more likely to repair and upgrade their products, instead of replacing them (Lobos, 2011). Products with strong emotional charge can go beyond individual connection with a user, enabling experiences that transcend families, communities and societies across multiple generations (Chapman, 2009). Emotional attachment can come from many different levels of interaction, ranging from feel, fit and finish, to perceived quality, durability, reparability, sentimental meaning and graceful ageing (Lobos, 2014). Based on these layers of emotional attachment, products with no unique attributes in terms of sustainability end up being valued by their users at significant levels (Van Nes & Cramer, 2003). The result is an extended lifespan that offsets the embedded environmental footprint needed to create the product in the first place.

3. Categories of sustainability potential

With the objective of aligning value and sustainability potential, below is a proposed list of five product categories that explores their relevance in people’s lives in order to determine their potential sustainability. These categories look at how different products satisfy basic notions of needs and wants, and from there offer superior levels of usability, pleasure, comfort, and sustainability. These levels can occur directly by means of materials and performance, and also indirectly by promoting sustainable behaviors. The categorization proposed below is not intended to be a comprehensive scale for assessing the sustainability of products as they are categories that wouldn’t necessarily fit under any of the five categories proposed. Its main goal is to better understand how users perceive product value and the impact that this has on consumerism and product lifespan.

3.1 Sub products

If the primarily reason for a product to exist is its ability to serve a function, sub products cannot fit in the category as they have no real function to serve. Examples of sub products include a helmet to hold toilet paper, covers for phone covers, USB pet rocks, umbrellas for shoes, and countless other products seen at gag gift stores. They are designed simply to create a laugh or a surprise that lasts a few minutes (Monbiot, 2012). Once this initial reaction fades they have nothing else to offer, turning them into waste. Products that fall under this category are no true products and sit at the bottom of
the chain. Sub products should not exist; they are like humans without soul, without a purpose in life.

Many products in this category are intended to be used just for fun, to create a funny reaction in whoever receives it. Even if products have a minimum level of utility to their users, society has gotten used to a throw-away model of consumption where products are underappreciated and easily discarded (Papanek, 2009). The issue with products that have extremely short lifespans is that they still require the same manufacturing efforts as useful products. Big Mouth Billy Bass, for example, was a sensor-activated signing fish that was fairly popular in the early 2000’s (See Fig.1). People loved giving or receiving a Billy Bass fish but hardly anyone used after its novelty passed. But in terms of complexity, this product involved an injection molded plastic frame, a flexible fish body made out of latex, and elaborate mechanical and electronic systems that played songs and made the fish move and open its mouth in sync as if it were signing. Products like this create a large carbon footprint but their lifespan is dramatically short, turning them into waste practically as soon as they are unpacked. Sub products are good examples of how natural resources are taken for granted, assuming that fabricating products like these have no larger consequences and are justified for offering nothing more than a laugh.

![Big Mouth Billy Bass signing fish. Photo by Rusty Clark (CC BY 2.0).](https://flic.kr/p/cXrMj9)

### 3.2 Ephemeral products

The next category looks at products that at least offer a function but they do it in a very limited way. Ephemeral products are those designed to sell but not to last. The reasons for this limitation could be
either by limited usefulness, short-term interests, single use scenarios, or by inferior quality (Nava, 2016). It is common to see them in infomercials products that address needs with very low success but that are presented in a seductive way to lure consumers into purchasing them. Products under this category can meet all expectations of function, usability and pleasure, and might even be good at all of them. Their issue lies in the fact that they were not designed to last a long time, but still used similar amounts of resources into creating them as other products that will outlast them. The issues of products with little real utility not only have direct impact in terms of the waste they generate but also desensitize users by making them think that products can be created easily, without effort and without consequences. New product introduction failure in the marketplace is alarmingly common, ranging from 40% to 90% depending on the category (Sok & O’Cass, 2015) and key reasons for this failure are the lack of connection to relevant user needs as well as the large amounts of products that are develop with inferior standards of utility, usability or quality.

When driven by low cost, ephemeral products offer similar attributes to successful ones, except that they are manufactured with inferior materials and engineering details, making them fragile, unusable and unreliable. The increasing speed of technological innovation and manufacturing is making society more used to a material culture that is expendable and disposable (Chapman, 2015). A common category for ephemeral products are knockoffs, which take advantage of popular products but create cheap versions, sometimes illegally (See Fig.2).
3.3 Regular products

Products under this category are not inherently sustainable. They are developed with traditional manufacturing methods that have no special considerations for reducing environmental impact. Additionally, they are subject to planned and perceived obsolescence, which deliberately limits their lifespan regardless of their actual performance (Lobos & Babbitt, 2013). Emotional design can be a key strategy to address planned obsolescence and turn regular products into objects that have long lifespans. If products are used long enough, chances are that users will become connected to them, extending their lifespan and offsetting whatever resources went into creating them. Emotional design is the key to turn regular products into special ones.

Achieving true sustainability is no easy task. There are plenty of examples of unintended negative consequences of design decisions, that even if made with good intentions, still compromise other stages in a product’s lifecycle (Blevis, 2007; Fuller & Ottman, 2004; Bray & McCurry, 2006). Let’s take for example a lamp made out of discarded computers or televisions. While the idea of keeping something away from landfills and giving it a second life is appreciated, a repurposed lamp could...
take electronic parts with delicate or even toxic components and put them in a context of general consumer goods. These materials could unintentionally be exposed to users, and when the lamp is discarded, would end up in landfills without special precautions and treatments that would occur if disposed as electronic waste.

For many people, sustainability can only be seen as a black or white matter, meaning that a product or system can either last forever or not. If its operation depletes resources, even at a very slow rate then it should be replaced by a better alternative that can last indefinitely. From this point of view, things cannot be kind of sustainable; they can either be carried on forever or they eventually will deplete resources. While this notion of absolute sustainability is valid, it also defines a practically unattainable goal and alienates most products out in the market. It is key that when products are evaluated in terms of their sustainability, this includes their emotional attachment and perceived value. Products that connect with their users offer an important sustainable potential that should not be overlooked. This potential would drive them from short-lived artifacts to objects that make a significant difference in their user’s lives and that overtime offer significant benefits to sustainability issues.

MUJI is a good example of regular products that become special. The Japanese brand of household goods focuses on simple, timeless designs with good quality and accessible prices. MUJI’s product development strategy includes selecting the right materials, optimizing production and simplifying packaging (Isomura, 2016). The simplicity and elegance of their products make them very attractive to consumers (See Fig.3) and their quality and durability assure that they can be used for a long time. This results in products that are valued by their users for a long time and that are built to last a long time. Not all MUJI products are developed in a “sustainable” way, meaning that they don’t always use recycled/upcycled components, but they are definitely developed with minimalism in mind, removing excessive materials, details or complexity.

Figure 3. Muji Stuff. Photo by Peggy Huang (CC BY-NC-ND 2.0). Available from: <https://flic.kr/p/7fWRwp>
3.4 Superior products

Products under this category are typically used as benchmark for good practices in sustainable design. The most important element that characterizes them is that they are developed with the entire lifecycle in mind. For some products, the focus might be on reducing environmental impact during manufacturing and better selection of materials while for other products the goal will be to reduce energy consumption during their operation or to improve the way that they are disposed of at the end of their lifespan (Deng et al., 2011). Sustainability tends to touch on very complex issues that encompass multiple stages in a lifecycle so it’s better to have specific goals that offer effective results rather than to try to solve every single issue that can occur around a product.

Once sustainability goals have been defined it is important to explore how different ways of addressing them would impact factors throughout the lifecycle. This step is critical to avoid unintended consequences and it also helps designers to keep a vision of all aspects of a given context even if they are focusing on specific problems (Mulder, et al, 2011). This exploration exposes tradeoffs that can affect a product’s performance directly or indirectly, and that designers should be able to identify and address.

In 2016 Adidas released to the market a limited edition of an athletic shoe made out of recycled plastic, specifically plastic bottles collected from the Hudson River in New York City (McAlone, 2016). The shoe, developed in collaboration with Parley for Oceans, offers an attractive and dynamic appearance (See Fig.4). The technological innovations of the shoe include an upper section made out of recycled materials collected from river streams, reducing water pollution. The shoe is also easy to recycle, which is an important feature given how quickly products in this category wear out and become unusable.

![Figure 4](https://flic.kr/p/BKppJ2)

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The midsole of the shoe was designed using generative techniques. This means that instead of having a solid piece of foam, it is an open tridimensional mesh. Generative design in this case is used to compute multiple iterations of complex structures that eliminate unnecessary material and bulk, leaving an organic structure that provides the necessary integrity and flexibility, as determined by pre-established specifications (Autodesk, 2016). By 3D printing the midsole instead of manufacturing it with conventional large-scale processes, it is possible to take advantage of additive fabrication methods to reduce waste and complexity. The impact of these methods has become standard in the footwear industry as Nike has been using 3D knitted uppers for their shoes for several years and New Balance recently released a commercial shoe with a 3D printed midsole. Superior products often change paradigms, drive technology and establish new approaches that redefine industries and markets.

3.5 Catalyst products

Some products go beyond efficiency and ecology, promoting their users to adopt sustainable behaviors. Sustainable performance of products can be measured at two levels: first is the innate performance of products themselves. This includes the energy and resources that they need in order to operate, as well as the embedded energy needed to fabricate them and the potential impact that they will have when they are disposed of. Manufacturers have most control over this level and it is their responsibility to develop products that minimize the environmental impact. The second level is how users operate them and how their behaviors lead to better performance (Lockton et al., 2008). As much as products are designed to consume little resources, for many categories their real impact depends on how they are used. Ideally, efficient products will be used in efficient ways but there is always the risk of a rebound effect where they are overused due to their superior performance (Hertwich, 2005). Rebound effect is common in energy efficient devices such as televisions and lightbulbs. If users overestimate their performance they will be likely to leave them on for hours at a time even if no one is using them, just because they consume little energy. It is also important to periodically assess the overall performance of a product and to know when it becomes more beneficial to replace it. This scenario is common in automobiles and major home appliances where older models are significantly less efficient than newer ones.

A good example of catalyst products can be found in household heating and cooling. According to the U.S. Department of Energy (2016), heating and cooling accounts for most than half of the total energy use in a typical home. While the type of system installed is key factor that determines energy consumption, residents’ use habits determine about 1/3 of the total energy consumption (Tang & Bhamra, 2009). Temperature is typically controlled with thermostats, which residents program initially but then forget to check and adjust periodically. This means that the temperature is likely to be over or under set as activities change in the household. The company Nest has taken a very different approach to temperature management (See Fig 5). Nest thermostats allow users to set their preferred temperature but also use sensors to monitor habits around the house, from when people get up in the morning or return in the evening to specific times of day when users are more likely to adjust the temperature. Nest uses this information to automatically adjust the ideal temperature throughout the day, based on user behavior. What makes Nest a true catalyst product is that it also offers features that make users involved in the process, driving behaviors further. For example, the thermostat turns its screen on whenever someone walks into the room or whenever the temperature is being adjusted, helping in making users more aware of temperature changes in their home throughout the day. Additionally, the thermostat has a leaf reward system that is shown on
screen as the system is used more efficiently. While the “leaf” rewards have no real value, users do know that the more leaves they receive, the more money they are saving in energy consumption.

Figure 5. Nest thermostat. Photo by Scott Cawley (CC BY-NC 2.0). Available from: <https://flic.kr/p/ny1PvC>

The idea of involving users in more responsible behaviors can be taken even further. Architecture firm ArchiBlox developed a pre-fabricated house that is carbon-positive, meaning that it produces more energy than what it needs to run (See Fig.6). In order to achieve this the house combines efficient cooling systems that run underground with an insulation system that minimizes energy waste (Frearson, 2015). In order for the house to be carbon positive, it needs to involve sustainable behavior from its inhabitants. The house’s sunroom is a key space that provides an open space that is inviting and relaxing but also creates a natural buffer zone for neutralizing hot and cold air zones in the house. The space brings in large amounts of natural light and also includes sections for growing plants and produce. The activities that could happen in these spaces go well beyond environmental benefit. Inhabitants could feel more accomplished with the living choices they make and could also seek more interaction with other residents or visitors. All of these behaviors are critical for enhancing personal growth and positive well-being, which are becoming key design elements for positive user experience (Casais, et al., 2015). ArchiBlox offers several models, ranging from 53 to 88 square meters (570 to 950 square feet), meaning that its intended for home owners who feel comfortable with the tiny house movement. The house’s design, however, is modular and resilient to eventual changes such as major repairs or expansions as needs of the homeowners change over time.
4. Conclusions

Sustainability is a concept that cannot be oversimplified. From materials and embedded energy to manufacturing processes, shipping and distribution, to user behavior and end of life options, sustainable products and systems need to pay attention to all steps in their lifecycle. Making decisions too quickly without understanding consequences across a product or system’s lifecycle can lead to unintended issues and environmental issues. But this complexity has also created the illusion of sustainable products being unattainable, meaning that they need to be developed in very special ways before they can be acknowledged as such. Most products in the marketplace do not follow strict sustainability guidelines, unfortunately, and while industry is looking at ways of closing this gap, there exists an abundance of products that are not optimized for sustainable performance.

Taking a new look at what sustainability means for industrial design use might provide new opportunities for ordinary products to become sustainable through extended use that offsets their environmental footprint. Some people assume that their products are not inherently sustainable or that their behaviors towards their products are not special, while in fact they make valuable sustainable choices. From electronic devices that are kept and used for several years, even if newer models are available, to tools that are shared by members of the same community. People are redefining their relationship towards products and this is something that needs to be acknowledged and celebrated.

Today’s marketplace unfortunately offers large amounts of products that don’t satisfy minimum levels of functionality or usability. Many of these sub products and ephemeral products don’t offer real value to their users, making them undesirable quickly but still needing large amounts of resources to be created and disposed of. Emotional design is an effective method for achieving this sustainability, by connecting products to their users in a meaningful way so that they can provide benefits over long periods of time. In order to achieve this connection, products need to have a solid foundation of functionality, usability and durability. Once these areas are covered, products begin to offer pleasure and superior experiences to their users. These attributes are necessary since adopted

Figure 6. Archiblox. Photo by Alpha (CC BY-NC 2.0). Available from: <https://flic.kr/p/qRni1p>

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sustainability requires time for products to connect with their users. As sustainable product design evolves, products can aspire to offer superior performance as well as key sustainability advantages. They can also promote user behaviors that generate positive and permanent changes in society at large scale and for generations to come.

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About the Authors:

**Alex Lobos** focuses on sustainability, emotional attachment and user-centered design. He is an Associate Professor and Graduate Director of Industrial Design at Rochester Institute of Technology, NY. Alex holds a MFA from the University of Notre Dame and a BID from Universidad Rafael Landivar.