PLATE

Product Lifetimes And The Environment

3rd PLATE Conference

September 18–20, 2019

Berlin, Germany

Nils F. Nissen

Melanie Jaeger-Erben (eds.)

Bakker, Conny: **Ten golden rules of design for sustainability**. In: Nissen, Nils F.; Jaeger-Erben, Melanie (Eds.): PLATE – Product Lifetimes And The Environment : Proceedings, 3rd PLATE CONFERENCE, BERLIN, GERMANY, 18–20 September 2019. Berlin: Universitätsverlag der TU Berlin, 2021. pp. 45–51. ISBN 978-3-7983-3125-9 (online). https://doi.org/10.14279/depositonce-9253.

Universitätsverlag der TU Berlin

3rd PLATE 2019 Conference
Berlin, Germany, 18-20 September 2019

Ten Golden Rules of Design for Sustainability

Bakker, Conny A.
TU Delft, Delft, The Netherlands

Keywords: Design; Guidelines; Sustainability; Circular Economy; Product-Service Systems.

Abstract: This paper presents a generic set of guidelines of Design for Sustainability (DfS), targeted at product and service design students. A literature review showed that almost all generic guidelines of DfS are over a decade old and relatively outdated. Recent DfS literature tends to focus on sector, life cycle stage or industry-specific guidelines. However, for students of design, having a number of state-of-the-art DfS guidelines that give an overview of the field, was considered useful as the field is currently experiencing a period of rapid development and renewal. For design researchers the guidelines can serve as a springboard for a debate on recent developments in design for sustainability. The paper presents the 'ten golden rules of design for sustainability' based on literature and the general discourse in the field. The ten golden rules are ordered according to the product lifecycle and include a system-level perspective. The rules are: (1) design adaptive systems, (2) design for net-positive impact, (3) go bio and renewable, (4) go clean, (5) do with less, (6) ensure equity and well-being, (7) support and shape sustainable lifestyles, (8) design for long use and reuse, (9) design for endings and (10) design for recovery.

Introduction

The field of product design for sustainability (DfS) has developed and branched out over the past three decades (Ceschin and Gaziulusoy, 2016). This is good because it indicates that, as a field of research and practice, design for sustainability is developing and maturing. The downside however is that the field has diverged to a point where it becomes very difficult for design students, and even for professional designers, to fully grasp the concept of 'design for sustainability' and find starting points for its operationalization. The objective of this paper is to develop an updated set of generic guidelines of DfS. More precisely, the objective is to create support tools in the form of guidelines or rules, for the design process of product-service conceptualization and development.

The main target groups are product and service design students and design researchers. For design students, it was proposed that the rules could be helpful as a generic mnemonic and to give direction and inspiration for their projects, and for design researchers they could serve as a springboard for a debate on the latest developments in the field of design for sustainability. Given that the most recent paper on generic Design for Sustainability guidelines was written in 2006 (Luttropp and Lagerstedt, 2006), this paper is considered a timely contribution to the field.

Background

The more recent papers that aim to provide guidance for DfS tend to focus on specific fields or subsets of DfS such as energy efficiency (Bonvoisin et al, 2010), recycling (Fakhredin et al., 2014), remanufacturing (Ijomah et al., 2007), repair (Flipsen et al, 2016), emotional durability (Chapman, 2015), 3D printing (Sauerwein et al, 2018), Computer-Human Interaction or HCI (Silberman et al., 2014, Knowles et al., 2018) and software (Becker et al., 2015). There is also a sizeable literature that deals with DfS guidelines for specific sectors or product categories such as fashion (Fletcher and Tham, 2015), medical systems (Kane et al, 2018), automotive (Schöggl et al, 2017), and even vending machines (Vezzoli and Sciama, 2006).

Both generic and specific guidelines are relevant in design; they have different purposes. Being involved in teaching design students the first principles of DfS, we felt the need for an updated generic set of guidelines that reflects recent shifts in perspectives in the field of Design for Sustainability.

Method

In this paper we follow Vezzoli and Sciama's (2006) definition of guidelines as "procedures to orient a decision process towards given objectives." We use the word 'rule' as synonym of 'guideline'. After developing a set of criteria for the guidelines, recent literature on Design for Sustainability was reviewed from the fields of product and service design, HCI, urban design and systemic design, taking care to include conference proceedings and grey literature as this is where interesting academic discussions tend to unfold first.

The following set of criteria was used for the development and choice of guidelines:
1. Life cycle focus. The rules should follow the principle of life cycle design (Vezzoli and Sciama, 2006), in particular "the extension of the design horizon from product design to the systemic design of all product life cycle stages." (p.1320)
2. Applicable to product-service systems, which were defined by Tukker (2004) as 'tangible products and intangible services designed and combined so that they are jointly capable of fulfilling specific customer needs." (p. 246). The rules should be valid for tangible (product) as well as intangible (service) design.
3. Newness. The guidelines should reflect the latest developments and most important new insights in the field of DfS, drawing from a variety of sources.
4. Generic. A small number of guidelines should be selected in order to give a generic overview the field without too much detail. Each guideline should give access to a deeper layer of knowledge and insights.
5. Inspirational and aspirational. The guidelines should be ambitious and give promising directions.
6. Non-redundancy and avoidance of conceptual overlaps. Each rule should represent a clearly separated area of concern.
7. Adaptability. Designers should be able to adapt the guidelines to their own project or process.

Results

The ten golden rules are listed in figure 1, ordered according to the product lifecycle stages of production, use and recovery, with 'system' added as an overarching category.

System

On system level, two rules try to capture the essence of systemic sustainable design. The first rule reflects a break away from an eco-modernist 'command and control' stance: **design adaptive systems**. Sustainable design is systemic by nature. This is for instance reflected by the recent 'systemic design' initiative, that aims to integrate systemic thinking and human-centered design to help designers deal with highly complex problems such as posed by the United Nations Sustainable Development Goals (Jones, 2017). Rather than claiming that design can come up with definitive solutions, systemic design aims for "aspirational change" through "better-fit processes and practices" (Jones, 2017). Sustainability is not a distinct point on the horizon, instead we have to acknowledge that we are in constant flux. As Håkansson and Sengers (2014) put it: "there is no such thing as a fixed 'sustainability' where change is no longer needed. Products, services and systems need to be open for ongoing change along the way." The design of adaptive systems, open for change and adaptation over time, is fundamental to a state-of-the-art Design for Sustainability methodology.
The second rule, **design for net-positive impact** stipulates that, through the design of adaptive systems, we should aspire to create products, services and systems that have an overall positive impact on the environment and on society. Net-positive outcomes have in the past decade become a topic of academic discussion in the field of sustainable architecture and urbanism. Birkeland (2012) for instance describes net-positive outcomes as able "to expand future options, diversity and ecology." Any design intervention in a system will have both positive and negative impacts. For instance, designing water filters for use in Africa will have a positive impact on overall health. But the environmental cost of producing the filters in China and transporting them to Africa, and the impact on household finances to purchase the filters, would have to be weighed against the potential benefits. Hertwich (2005) warns us to be aware of these rebound effects, which are behavioural and systems responses to an intervention. Hertwich argues that any design intervention aimed at solving a particular problem will show co-benefits, spillover effects and negative side effects and these need to be understood in order to increase the chance of a design intervention having a net-positive impact. Essential in this process, according to

Birkeland (2012), is to move away from design approaches that encourage "choosing among alternatives" as this results in 'trade-off thinking' that allows social gains to balance out ecological losses. Instead we should aim to design "new synergistic alternatives." This requires the development of tools that assess designs on a positive scale while taking into account potential rebounds, which is an underdeveloped field. On a policy level, the EU has started to put in place a system of natural capital accounting (La Notte et al, 2017), which may, in time, inform the development of new design tools.

Figure 1. The 10 Golden Rules, see appendix for larger version.

Production

The many eco-design guidelines that are related to the production of materials and products tend to converge on one topic: reduction. Reduction of materials and energy consumption, reduction of production waste, reduction of transport, reduction of toxic and other harmful substances, etc. (for instance, van Hemel and Cramer, 2002, Luttrop and Lagerfeld, 2006). We decided these guidelines needed reframing. The climate crisis (Carrington, 2019) requires us to do more than reduce and optimize. The third rule, **go bio and renewable** addresses the urgency to keep global temperature increase below 1.5°C by a rapid and far-reaching transition towards a low-carbon economy (IPCC, 2018). This requires us to embrace alternatives for fossil-based materials and energy sources. Future polymers, for instance, will increasingly be biodegradable and bio-based (Lambert & Wagner, 2017) and designers will have to learn how to design with these, as well as with renewable energy technologies such as photovoltaics, wind and hydrogen-based systems.

The fourth rule, **go clean,** is about ensuring that the products and services we develop and the materials and processes we specify, cause no harm to human health, are non-critical (Köhler et al., 2013) and do not pose toxicity and other detrimental risks to ecosystems. The recent attention for marine microplastic pollution (for instance Haward, 2018) has put 'go clean' firmly back on the design agenda.
The fifth rule **do with less** reflects the need for designers to attain absolute reductions in (both renewable and non-renewable) materials and energy consumption and to consider sufficiency in consumption. Decoupling economic growth from its material impacts has proven not to work. Jackson (2009) proposes that we need to find new ways to define prosperity, without growth. Translated to design, sufficiency touches upon the very roots of our profession, for should we – can we - decide *not* to design?

Use

Sustainable design strives to end poverty and improve well-being through products and systems that support universal access to better nutrition, healthcare, education, information, housing, clean water and basic sanitation. This is reflected in the sixth rule, **ensure equity and wellbeing**. This rule is inspired by the United Nations Sustainable Development Goals. As it covers a wide and important area with much design activity that we cannot do justice in the limited space of this paper, we refer to the descriptions and targets of the SDGs for extensive information and data (UN, 2015). The seventh rule focuses on behaviour change through design. A field of vigorous design research interest, it asks how design can intervene in everyday life to **shape and support sustainable lifestyles** for (groups of) people and communities. A multitude of approaches and methods has sprung up. Among the modernistic approaches are for instance Design for Sustainable Behaviour (e.g. Lilley, 2009) that looks at design as a 'lever' to which an individual will respond by changing his/her behaviour. On the other end of the scale are the constructivist approaches that consider everyday practices to be socially constructed, both stable and changeable in time. This makes behaviour change a collective, social process rather than an end-point (Kuijer and Bakker, 2015) and requires design to adopt co-creation and action research as part of its toolbox (Tromp and Hekkert, 2019, Håkansson and Sengers, 2014). Rule number eight, **design for long use and reuse**, was included as a

response to consumerist trends such as the increasing rate of change in the fast fashion industry (Day et al, 2015), the proliferation of plastic disposables (EC, 2019) and the long-term decrease in repairability of devices such as smartphones (ifixit, 2019). Design for long use and reuse is about creating products that last and that can be loved and cherished, maintained, repaired, reused, upgraded, adapted, personalized, refilled and repurposed for as long as possible (Bakker et al, 2014, Van den Berg, 2015).

Recovery

In an economy that should increasingly focus on becoming more circular and that should maintain high-value and high-quality material cycles (Korhonen et al., 2018) it is no longer useful to talk about 'end of life' of products, as this suggests a rather linear lifecycle from cradle to grave. Instead, we use the word recovery to highlight the strategic importance of recovering obsolete products and materials, and looping them back into the economic system (Den Hollander et al, 2017). Recovery is probably one of the least researched Design for Sustainability areas. The ninth rule, **design for endings** reflects the key role consumers have in closing resource loops (Zeeuw van der Laan, 2019, Selvefors et al., 2019). For a consumer or user, ending the engagement with products and allowing these to flow back into the economic system, is an important, but generally overlooked, part of consumption (Macleod, 2017). Design for endings aims for well-designed and respectful 'offboarding' experiences. The tenth and final rule, **design for recovery** focuses on value retention processes such as refurbishment, remanufacturing and recycling. This requires the development of design strategies that help create, preserve and recover value, which gives design for recovery a strategic edge, because value retention processes can "support growth opportunities ... by targeting and engaging new, previously untapped, market segments that are underserved by OEM new products" (IRP, 2018).

Discussion and conclusions

Having developed the set of 10 golden rules, we will evaluate these against the criteria in the method section. Regarding the first criterium, the golden rules clearly follow the principle of life cycle design, starting from a systemic view and following the three major stages in a product's life, production, use and recovery. Its applicability to product-service-systems (criterium 2) is however open to debate. The 10 rules have a bias towards tangible products. We struggled to find ways to incorporate intangible product services (including digitization) into the guidelines, and the lack of literature on this topic is a sign that more exploration is needed here. For instance, dealing with software sustainability has been addressed by Becker et al. (2015) but the resulting manifesto still needs to be translated into usable guidelines for product-service designers. With regard to criterium 3, the rules try to reflect new insights in the field of DfS. It is quite possible that aspects were overlooked, or not given the spotlight they deserve. For instance, the renewed attention for transition design (Lockton and Stuart, 2018) or for the existential crises we are facing (Fritsch, 2018) may, in time, lead to new guidelines.
The choice for 10 rules (related to criterium 4) is somewhat arbitrary, and was critiqued during discussions with colleagues (see below). Regarding criterium 5: the rules are certainly ambitious and an attempt was made to reframe them away from a reductionist approach. Criterium 6 asks for non-redundancy and avoidance of conceptual overlaps. Each rule does represent a separated area of concern. However, the two systemic rules are, by nature, broad and inclusive and operate on a higher level of abstraction. A certain overlap between the 'system' and other rules is unavoidable.
Finally, according to criterium 7 designers should be able to adapt the guidelines to their own project or process. This has not been tested in practice yet.

The evaluation of the rules against the criteria is a first internal validation. Additional internal validation will have to be done by discussing the rules with independent DfS experts, and an external validation would involve testing the rules with students in a design project. A first debate with colleagues of the Design for Sustainability research group at TU Delft led to the following critiques of the 10 Golden Rules:

- The choice for 10 rules comes across as arbitrary and unscientific. Why not 12 or 8 rules?
- Economic sustainability ('prosperity') is not taken into account.
- A meta-guideline is missing that argues that all 10 rules should be considered as interdependent, to prevent students from cherry-picking.

- There is nothing on ethics (not directly, at least) or sustainability assessment.

It follows that creating a compact set of up-to-date generic DfS guidelines is not a scientifically rigorous process. Choices need to be made, and this inevitably reflects some of the biases of the creator of the guidelines. The ten golden rules should be regarded as a discussion piece; the intention is not so much to reach consensus (which may be an elusive goal), but to spark conversation and debate. It is also important to realize that no set of guidelines is ever fixed; guidelines can and should evolve in time. We hope that the 10 Golden Rules will lead to renewed debate in the field, drawing on insights from different disciplines, and that they might offer design students some guidance and a first window into the complex but fascinating world of design for sustainability.

Acknowledgments

The authors wants to thank the colleagues from the Design for Sustainability research group at the Faculty of Industrial Design Engineering for their animated feedback and helpful discussions regarding the 10 Golden Rules.

References

Bakker, Conny, Marcel den Hollander, Ed van Hinte and Yvo Zijlstra (2014) Products that Last; product design for circular business models. TU Delft.

Birkeland, J. (2012) Design Blindness in Sustainable Development: From Closed to Open Systems Design Thinking, Journal of Urban Design 17:2, 163-187

Becker, C., Chitchyan, R., Duboc, L., Easterbrook, S., Penzenstadler, B., Seyff, N., & Venters, C. C. (2015, May). Sustainability Design and Software: The Karlskrona Manifesto. In 2015 IEEE/ACM 37th IEEE International Conference on Software Engineering (ICSE) (pp. 467-476). IEEE.

Bonvoisin, J. Mathieux, F., Domingo, L., Brissaud, D. (2010) Design for energy efficiency: proposition of a guidelines-based tool. Proc. International Design Conference - DESIGN 2010, May 2010, Dubrovnik, France. hal-00524240

Carrington, D. (2019, May 17) Why the Guardian is changing its language about the environment. The Guardian. Retrieved from https://www.theguardian.com/environment/2019/may/17/why-the-guardian-is-changing-the-language-it-uses-about-the-environment

Ceschin, F., Gaziulusoy, I. (2016) Evolution of design for sustainability: From product design to design for system innovations and transitions. Design Studies, Vol. 47, 118-163.

Chapman, Jonathan (2015) Emotionally Durable Design; Objects, Experiences & Empathy (2nd edition) Routledge, London

Day C., Beverley K. and Lee A (2015), Fast Fashion, quality and longevity: a complex relationship, Proceedings of PLATE conference, Nottingham Trent University, UK.

Den Hollander, M.C., C.A. Bakker, H.J. Hultink (2017) Product design in a circular economy; development of a typology of key concepts and terms, Journal of Industrial Ecology 21 (3), 517-525.

European Commission (2019, May 21) Circular Economy: Commission welcomes Council final adoption of new rules on single-use plastics to reduce marine plastic litter. Press release from European Commission, retrieved from http://europa.eu/rapid/press-release_IP-19-2631_en.htm

Fakhredin, F., C.A. Bakker, J.M.P. Geraedts (2014) Designer focused quickscan recyclability assessment method. Proceedings of CARE Innovation 2014 “Going Green” Conference, Vienna, Austria, 17-20 November 2014.

Fletcher, Kate and Mathilda Tham (2015) Routledge Handbook of Sustainability and Fashion, Routledge, UK.

Flipsen, Sebastian F.J., Conny A. Bakker, Guus L.A. van Bohemen. (2016) Developing a Repairability Indicator for Electronic Products. In: Proceedings of Electronics Goes Green 2016, Sept 7-9, Berlin, Germany. Published by Fraunhofer IZM and Technische Universität Berlin.

Fritsch, Jonas (2018). Affective Interaction Design at the End of the World. Proc. DRS 2018. Design Research Society, Limerick.

Håkansson M., Sengers Ph. (2014) No easy Compromise, Sustainability and the Dilemmas and Dynamics of Change. Proc. DIS’14, ACM, 1025-1034.

Haward, M. (2018) Plastic pollution of the world’s seas and oceans as a contemporary challenge in ocean governance, Nature Communications vol.9: 667, 1-3.

Hertwich, E. (2005) Consumption and the rebound effect: an industrial ecology perspective. Journal of Industrial Ecology, 9, 85-98.

Ifixit (2019). Repair Market Observations. Internal ifxit report, April 30, 2019. Retrieved from https://www.ifixit.com/News/why-right-to-repair-matters-our-testimony-to-the-ftc

Ijomah, W.L., McMahon, C.A., Hammond, G.P. and Newman, S.T. (2007) Development of robust design-for-remanufacturing guidelines to further the aims of sustainable development. International Journal of Production Research, 45, 18-19.

IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

IPR (2018) Re-defining Value – The Manufacturing Revolution. Remanufacturing, Refurbishment, Repair and Direct Reuse in the Circular Economy. Nabil Nasr, Jennifer Russell, Stefan Bringezu, Stefanie Hellweg, Brian Hilton, Cory Kreiss, and Nadia von Gries. A Report of the International Resource Panel. United Nations Environment Programme, Nairobi, Kenya.

Jackson, Tim (2009) Prosperity without Growth — economics for a finite planet. London, Routledge.

Jones, Peter (2017) The Systemic Turn: Leverage for World Changing. She Ji: the Journal of Design, Economics, and Innovation, 3(3), 157-163

Kane, G.M., C.A. Bakker, A.R. Balkenende (2018) Towards design strategies for circular medical products, Resources, Conservation and Recycling 135, 38-47

Knowles B., Bates O., Håkansson M. (2018) This Changes Sustainable HCI, Proc. CHI'18, ACM. Paper no. 471, 1-12.

Köhler, Andreas R., Conny Bakker, David Peck (2013). Critical Materials: a reason for sustainable education of industrial designers and engineers. European Journal of Engineering Education, 38 (4) 441-451.

Korhonen, J., A. Honkasalo, J. Seppälä (2018), Circular Economy: The Concept and its Limitations, Ecological Economics 143 (2018) 37–46.

Kuijer, Lenneke and Bakker, Conny (2015) Of Chalk and Cheese: behaviour change and practice theory in sustainable design. International Journal of Sustainable Engineering 8 (3), 219-230.

Lambert S., M. Wagner (2017), Environmental performance of bio-based plastic, Chem. Soc. Rev., 46, 6855-6871.

La Notte, A., Vallecillo, S., Polce, C., Zulian, G.,Maes, J. (2017) Implementing an EU system of accounting for ecosystems and their services. Initial proposals for the implementation of ecosystem services accounts, EUR 28681 EN; Publications Office of the European Union, Luxembourg, JRC107150.

Lockton, Dan and Candy Stuart. (2018) A Vocabulary for Visions in Designing for Transitions. Proc. DRS 2018: Design Research Society, Limerick.

Luttropp, C. and Lagerstedt, J. (2006) EcoDesign and the Ten Golden Rules: generic advice for merging environmental aspects into product development. Journal of Cleaner Production, vol. 14: 15-16, 1396-1408.

Macleod, Joe. (2017) Ends. Why we overlook endings for humans, products, services and digital. And why we shouldn't. ISBN 978-9163936449.

Sauerwein, Mariet, Zjenja Doubrovski, Ruud Balkenende, Conny Bakker (2019). Exploring the potential of additive manufacturing for product design in a circular economy. Journal of Cleaner Production 226, 1138-1149.

Schöggl J.P., Rupert J. Baumgartner, Dietmar Hofer (2017), Improving sustainability performance in early phases of product design: A checklist for sustainable product development tested in the automotive industry. Journal of Cleaner Production, 140, 1602-1617

Selvefors, A., Rexfelt O., Renström S., Strömberg, H. (2019) Use to Use – a user perspective on product circularity. Journal of Cleaner Production, 223, 1014-1028.

Silberman, M., Lisa Nathan, Bran Knowles, Roy Bendor, Adrian Clear, Maria Hakansson, Tawanna Dillahunt, and Jennifer Mankoff (2014). Next steps for sustainable HCI. Interactions 21 (5), 66-69

Tukker, A. (2004) Eight types of Product–Service System: Eight Ways to Sustainability? Experiences from Suspronet. Bus. Strat. Env. 13, 246–260.

Tromp, N. and P. Hekkert (2018) Designing for Society; products and services for a better world. Bloomsbury, UK.

United Nations (2015). Sustainable Development Goals. UN. Retrieved from: https://sustainabledevelopment.un.org/?menu=1300

Van den Berg, M.R. and C.A. Bakker, A product design framework for a circular economy. In: Cooper, Tim et al. (ed), Proceedings of the Product Lifetimes and the Environment conference (PLATE), Nottingham, UK, June 2015.

Van Hemel, C., J. Cramer (2002) Barriers and stimuli for ecodesign in SMEs. Journal of Cleaner Production. 10(5) 439-453.

Vezzoli, C., Sciama, D. (2006) Life Cycle Design: from general methods to product type specific guidelines and checklists: a method adopted to develop a set of guidelines/checklist handbook for the eco-efficient design of NECTA vending machines. Journal of Cleaner Production 14: 1319-1325.

Zeeuw van der Laan, A. and M. Aurisicchio (2019) Archetypical consumer roles in closing the loops of resource flows for Fast-Moving Consumer Goods. Journal of Cleaner Production, in press, retrieved from https://doi.org/10.1016/j.jclepro.2019.06.306

Appendix

Figure 1. The 10 Golden Rules of Design for Sustainability (large version).