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Towards a Quantified Design Process: bridging design and life cycle assessment

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Abstract

In this paper the authors describe how design researchers and environmental researchers, in the ongoing Mistra Future Fashion programme (2011-2019), are making a joint effort in overcoming the disciplinary barriers for collaboration. By comparing existing processes and identifying potential opportunities arising from inter-disciplinary collaboration the aim is to propose methods for building a bridge between disciplines. A model for "quantified design" is generated, and explored, relevant for designers, design researchers as well as LCA researchers.

Introduction

There is broad consensus that the sustainability challenges of the fashion and textiles industry could be better met through a multi-disciplinary approach (Börjeson et al., 2014). Designers, design researchers and environmental researchers need to collaborate, but there can be difficulties in doing so, with scientific analysis and creativity seemingly at odds, even when both are aiming towards better environmental solutions. It is not unusual to design multi-disciplinary research projects, however, the administrative project set-up is seldom enough to bridge the disciplinary gaps (Sandin et al., 2014). There is also need for inter-disciplinary understanding to provide joint results. The overarching aim of the Mistra Future Fashion project is to attain 'systemic change' in the Swedish fashion industry leading to sustainable development. This aim requires collaboration from actors across multiple disciplines including design, material and social sciences. In order to combine the highest level of research across these disciplines towards a common goal it is essential to move towards a common language and means of combining insights in all areas. In this project researchers are attempting to find solutions and best practice towards this aim. This paper explores the interrelation of two stakeholders (design & environmental science) through proposing a pilot project to combine their processes into a singular and interrelated approach. The scientific theory development behind the design research process and the environmental science research process have both similarities and differences.

The LCA Model

The key environmental assessment process in use in Mistra Future Fashion is Life Cycle Assessment (LCA) as defined by the ISO 14040 standard (ISO, 2006). LCA is today an important holistic process for comparison of alternative solutions for environmental performance improvement, used by governments, industry and academia. The relevance for policy-making has increased the recent years, as the European Ecodesign Directive (European Commission, 2009) as well as the European Commission initiative for Product Environmental Footprint (PEF) are based on LCA (European Commission, 2013). LCA is commonly performed in multi-disciplinary research projects (Sandin et al., 2014). In using LCA for environmental research, the limitations of the method should also be known. LCA assesses exclusively to impacts that are potentially caused by physical inflows and outflows between the analysed system and the ecosphere, and caused during normal and abnormal operating conditions of the included processes, but excluding accidents, spills, and the like (European Commission, 2010). The environmental aspects that cannot be quantified are excluded, and important qualitative information may be lost. The absence of some important sustainability aspects in LCA has encouraged the development of other life cycle thinking processes such as social LCA and life cycle costing. The latter evaluates financial impacts of alternative products, while the former considers the social impacts associated with product design. As the application of SLCA to fashion design is relatively new (Zamani et al, 2016) and the methods are controversial (Arvidsson et al, 2014) it will not be discussed further in this article.

LCA differs from many other processes in the chemical and environmental sciences in that it is based on systems analysis (Baumann and Tillman, 2004). In systems analysis, method development is commonly based on empirical experiences from case studies (inductive or abductive perspective) (Miser and Quade, 1985). The classic chemical and environmental sciences are very often based on the deductive perspective, often using reductionism to test theories of cause-effect, though the biology branch of environmental science early discovered system-level effects (von Bertalanffy, 1968). Dubois and Gadde (2002) describes the abductive logic-based systematic combining approach as particularly useful for development of new theories, letting theoretical framework, empirical fieldwork, and case analysis evolve simultaneously, in case studies where when the boundaries between phenomenon and context are not clearly evident. As systems analysis methods are difficult to validate, case studies can also be used to provide proofs of concept (or calls for adjustments) of the developed method and theory (deductive perspective) (Miser and Quade, 1988).

The Design Model

Systems thinking is also at the centre of the design model adapted by design researchers in this project. However, unlike the LCA process the 'system' is explored and tested through the realisation of a 'prototype'. In many ways the whole iterative experience of designing can be described as prototypical. Although the prototype itself can take on different roles within the design research itself. Design researchers in Mistra Future Fashion have been using the 'prototype' as both a 'thinking process' (setting the future scenario) and as a 'proposal for evaluation' (a future product ready to be analysed).

Firstly, by building prototypes based on a future scenario towards a systemic ideal researchers are adopting a speculative design approach. This approach based on Dunne & Raby's vision (2013) of design as a 'tool to create not only things but ideas.' In this version of design, speculation can inform how 'things could be' to imagine possible futures. In order to propose 'systemic change' an understanding must be reached of the changes and impacts that can be affected. Both 'intended and unintended consequences' of design decisions must be considered throughout the 'whole' lifecycle of the product in close collaboration with scientific partners.

Tim Brown (IDEO), in Change by Design, cites the production of prototype in design, as a fluid system for the exploration of ideas: 'Design thinking is inherently a prototyping process. Once you spot a promising idea, you build it. In a sense, we build to think.'

'Innovation starts with a story about the future. Imagining and sharing desires and fears about the futures is a way for all of us to shape it… By articulating the changes needed to bring a preferred future to life, we can fix the shape of the future in a previously uncertain landscape.' (Bland & Westlake, 2013, p18)

'By creating scenarios around these 'what if' questions with tangible and realistic objects, designers can fabricate an experience of that possible future. Looking forwards in time allows us to imagine problems that might still be beneath the surface or factors that are unknown but plausible or possible.' (Nesta, 2016)

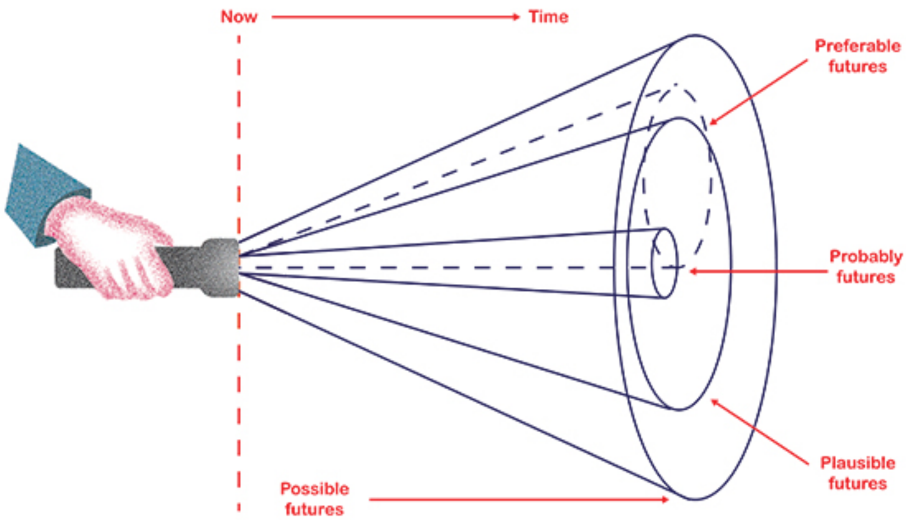

Figure 1. Nesta (2016) The Futures Cone diagram above imagined the cone as a torch beam. Available at http://www.nesta.org.uk/blog/speculative-design-design-niche-or-new-tool-government-innovation

Secondly, the prototype can act as a focus for cross-disciplinary discussion and communication of ideas, in the hope that these ideas will go some way towards changing mindsets, an essential aspect towards achieving systemic change.

To achieve sustainability through design, collaboration across disciplines can reduce the potential damage resulting from existing practices. A product can be redesigned to improve its overall performance, by understanding its context in a system. 'Re-directive practice' results in what Fry describes as design 're-coding': 'the exposure of the unsustainable and the declaration of means of sustainment.' When this is embodied in a prototype, the reflective 'conversation' takes place in a series of project revisions. As a result of surprise realisations or 'backtalk' from the prototype, the designer can test, redesign and collaborate with other disciplines and ultimately, with the consumer, who can become part of the prototype community. (Winograd.1996)

When the models clash and integration is needed

Experiences in the first phase of the programme (2011-2015) showed that practical integration of the work of designers and environmental assessors was an interesting challenge. For need for designers to be empowered by creative flexibility during the design project hampers the LCA analyst's desire to be as clear about the goal and scope of the LCA at the outset as possible. The focus on design principles and conceptual approaches to sustainability for example embodied in TED's TEN (http://tedresearch.net/teds-ten/) differs from the desire for numerical quantification of impacts, which is embodied in LCA and LCA-based ecodesign methods and tools. These different needs and desires lead to different vocabularies for expressing garment sustainability among designers and environmental assessors.

Current Combined Models

The list of available methods and tools for utilising LCA results in decision-making in product design processes, so-called 'ecodesign', is extensive. For example, Bovea and Pérez-Belis (2012) presented a summary of available environmental tools together with a taxonomy, and Pigosso et al. provided another overview of 112 ecodesign tools together with a scheme for diagnosis of the current maturity profile of a company's product development and proposal of the most suitable ecodesign practices to be applied (Pigosso et al., 2013). Some of the most famous ecodesign method developers relate to product design (Charter and Clark, 2008; Boks, 2006; Lindahl, 2006; Dewulf and Duflou, 2004; Luttropp and Lagerstedt, 2006; McAloone and Bey, 2009). Although the proposed ecodesign methods have a number of common elements, they do not occur in the same order. Important common elements include the process of transparently defining stakeholders in the design process, defining the product to be designed, identifying the supporting systems, detailed options analysis (for example, using lifecycle assessment tools) and synthesising strategy. These approaches provide useful guidance for the integration of LCA and design in Mistra Future Fashion.
The process of integrating the fashion design research and environmental science processes has however not been studied before. Many studies show that the implementation of ecodesign is not so simple as to make methods and tools available even if the tools are at hand the problem is rather that they are not used enough. The theories and research areas

about ecodesign implementation in both product development and research processes can be categorised as:

- frameworks for categorising companies maturity in incorporating sustainability considerations in their product realization (Alakeson and Sherwin, 2004; Pigosso et al., 2013).
- the role and challenges of integrating ecodesign in the early product development, the fussy front end, and the two different processes for development of new products on the one hand and incremental development of existing products on the other hand (De Medeiros et al., 2014).
- the main obstacles of successful integration of ecodesign include the same areas of concern that general organisational and product development issues but also in particular lack of motivation and competence (Baumann et al., 2011; Jönbrink and Melin, 2008; Sandin et al., 2014).
- addressing 'the soft sides of ecodesign' as an important area of research, increasing the knowledge of how to work with the weak link between attitudes and behaviour, motivation and responsibility in decision making (Boks, 2006)
- the language and communication playing a crucial role, and the under-researched link between ecodesign proponents and the executors (technical experts, decision makers and marketing experts especially) (Charter and Clark, 2007)

More work is needed to study how the particular characteristics of fashion design research and LCA research can be integrated.

Method

The proposed method for the study involves an integration of the design research and environmental science methods into a combined process which for the purposes of this paper is called 'quantified design'. It will involve a number of multidisciplinary workshops where both research processes are merged and responsive to one another, building a new understanding, whereby the impact on the environment acts as an integrated part of the design brief and informs each stage in the design concept development.

Process for Combined Model

The proposed 'combined model' can be broken down into the following steps:

Garment Level Case Study
(narrative development based on LCA factors)
Several prototype garments are under investigation in the second phase of the research programme), among them a paper jacket, a laser-finished recycled polyester dress and an upcycled polyester shirt, all from the 2015 'Textile Toolbox' exhibition (Earley & Goldsworthy, 2016) and will act as case study objects for this inter-disciplinary analysis. Typical questions around the prototypes will be posed from design researchers to LCA researchers based around the product lifecycle scenarios: what if they are worn more times, produced locally, require less washing etc. Typical questions from the LCA researchers to the design researchers might be: what are the prototypes meant to represent, what is the aim of the LCA study etc. This part of the proposed 'combined model' process will be used to highlight and record potential obstacles for collaboration such as the different perspectives, agendas, vocabulary etc.

The outcome of this stage in the process will be a fully developed 'lifecycle narrative' which is informed by the LCA metrics and allows our speculative design prototype to be assessed in terms of these impacts even before it is a physical product. Assumptions will of course need to be made about its production methods, material construction and use among others, but by deciding on these assumptions collaboratively with scientist and design bringing different perspectives it is hoped that the resulting narrative might be closer to an industry reality than might otherwise be achievable.

Assessment of Existing Case Study Narratives
Once these existing product scenarios are fully defined through the above process a second stage will involve an outline of the LCA implications of these case studies based upon the research carried our in the first phase of the project. These LCA narratives will then be further explored with the designers in order to refine and make sense of the case studies.

Scenario Development Based on Case Study Narratives (fast and slow adaptations)

Each case study narrative will then be developed further into alternative scenarios focussed on two main adaptations; one to extend the use phase of the garment through material and emotional durability qualities (extended life products) and another to shorten the use phase and focus on lighter production and efficient recycling (short-life products). These second-tier scenarios will be fully described as for the existing ones through a product narrative and specification.

LCA Implications of new Design Scenarios

The adapted product scenarios will then be reassessed by the LCA researchers in order to prompt discussions around where the key benefits of different design decisions may be. To what extent might these scenarios improve environmental impacts or create new ones at further stages along the lifecycle?

Realisations of new Design Scenarios (prototypes)

The final design concepts will be realised into creative material artefacts, or prototypes, which will act as communication and exploration of the combined process. The LCA insights become effectively part of the design brief and are responded to through this realisation process. This step may offer further insight which could lead to future developments.

Steps three to five may be rerun as cycles or iterations to refine both the narrative and the LCA analysis until it reaches a point of insight between both designer and LCA practitioner.

Results

Comparison of Research Processes

While science aims to explain how things are, design aims to explore how things should be by finding a solution to a problem and improving the current status quo. The problem itself can be something concrete like an unergonomic chair. But, the problem can also be as substantial as a public transport infrastructure or how a business should plan its goals. At either end of the scale, the aim of a design process is always to improve the future, which is why the future is often a dominant factor in different design activities.

Existing Separate Models

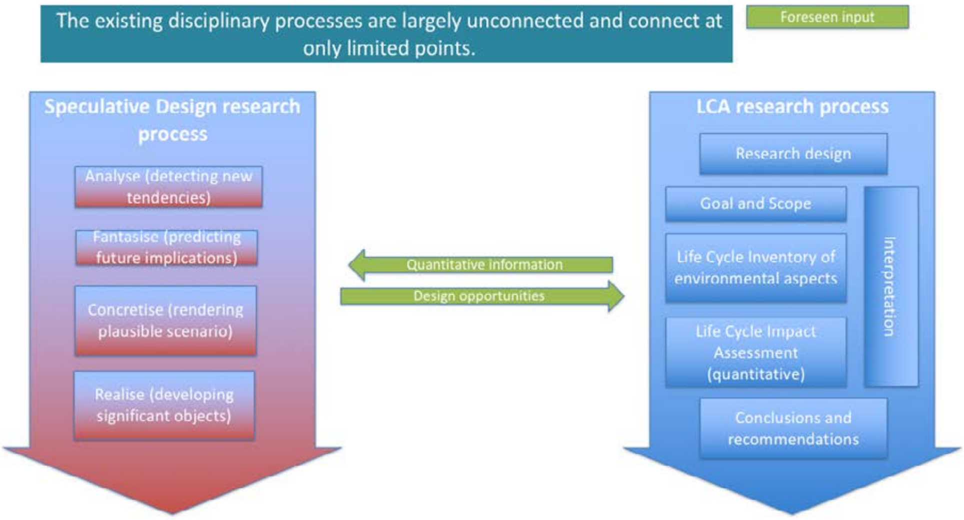

Figure 2. The Above figure demonstrates two existing but separate models for LCA and Design Research. These disciplinary processes are largely unconnected and interact only at limited points, whereby design outcomes might be used to influence the early stages of LCA modeling and LCA might be part of initial design inputs.

Proposed Combined Model

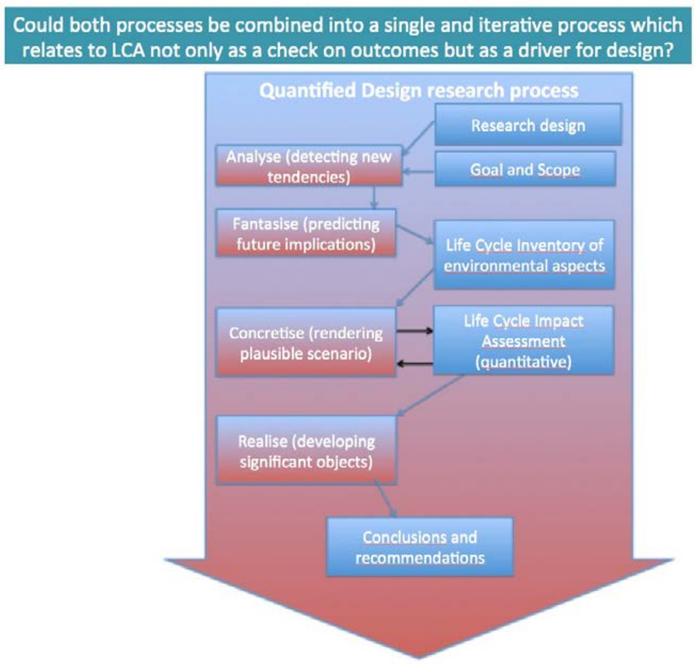

Figure 3. This combined model is a proposition for fully integrating the design and environmental science process into an iterative design & environmental process. To be tested through the Mistra Future Fashion programme Phase 2, 2015-2019

Discussion

The clash between the worldviews can perhaps be explained by the different perspective applied by design researchers and LCA researchers respectively regarding consequences. The consequential perspective can be divided into different orders (Sandén, 2012):

- 0 order consequences: direct physical effects
- 1st order consequences: linear systemic response (technical or physical mechanism)
- 2nd order consequences: systemic response governed by negative feedback (economic mechanisms)
- 3rd order consequences: systemic response governed by positive feedback (socio-technical mechanisms)

The zero order consequences are what LCA researchers generally put into the quantitative system model: resource consumption and emissions from real-life textile production processes. On zero order system level, the consequences of that a consumer buys a garment, are actually none. The garment is produced several months earlier and the effects on the environment have already occurred.

The first order consequences are often the main focus for the LCA researcher. Technical interventions in terms of new machinery, alternative chemistry and so forth, as well as physical interventions in terms of quantity of produced goods or new production locations are the focus for the LCA-based ecodesign guidelines. On the first order system level, the environmental gain is easily quantified and can be translated into the direct physical effects

The second order system level is where the design interventions begin to show. The garment design impacts the economic mechanisms, and depending on the size of the available stocks of products, the effects on first order system level arise at some point in time. At the second order system level, the consequences are no longer purely mechanistic, and LCA researchers part from the previous stricter physical process descriptions and begin to draw so called "scenarios" of possible first order consequences. The scenarios are more exploratory than descriptive and are aiming at capturing which decisions that might be environmentally beneficial or not

The third order consequences are systemic changes due to accelerating learning curves and institutional changes. Here is where the design researchers have their main focus. The fashion design development is no longer limited to incremental improvement of existing products but there is space for invention of fashion items with entirely new ways of meeting consumers' needs.

The proposed method for handling the clash of the models in the project is to visualize the differences. The two processes can then be combined into a single and iterative process of meeting and discussing the different worldviews in a set of workshops. The preliminary model generated for 'quantified design' is aimed to be inclusive enough to leave room for both engineering and artistic mindsets, and relevant for designers, design researchers as well as LCA researchers. This stands well in line with previous knowledge of ecodesign implementation seeing that the language and communication play a crucial role for success (Charter and Clark, 2007).

Conclusions

The sustainability challenges of the fashion and textiles industry could be better met through a multi-disciplinary approach. However, in the review of the literature on design models and ecodesign implementation, it was found that descriptions of practices for how design researchers and environmental researchers can overcome the disciplinary barriers for collaboration are scarce.

This paper aims to address this need by providing a practical example of the model in development by the authors. The background to this combined model has also been described, as it was performed in two steps. In the first step the literature on scientific theory development behind the design research process and the environmental science research process was investigated as a way to find similarities and differences that could contribute to mutual understanding. The disciplines were found to be quite far apart. While science aims to explain how things are, design aims to explore how things should be by finding a solution to a problem and improving the current status quo.

The second step was to combine the two different worldviews into a 'combined model for quantified design'.

Future work includes validating and improving the model by empirical case studies. Through the 'combined model/quantified design' process it is hoped that new insights may be drawn which relate scientifically based environmental impact research to the design process. By integrating these two models a new, iterative one emerges which places circular design at the centre of the design process and is backed up by scientific evidence. By developing scenarios which polarise the designed-in 'speeds' of a fashion product it is hoped that insight will be gained into the 'direction of travel' of impacts relating to fundamental design decisions. It is not intended that 'absolute' metric judgements will be made, rather that design decisions will be linked to impacts on a scale which a designer may understand and utilise in their process.

The project will be completed in 2018 and further results published through Mistra Future Fashion.

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