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WHY DESIGNERS WON'T SAVE THE WORLD

Victor G. Martinez Kwantlen Polytechnic University Victor.martinez@kpu.ca

Stuart English Northumbria University Stuart.english@northumbria.ac.uk

ABSTRACT

Despite a large body of research into sustainable design, evidence suggests that designers rarely put this knowledge into practice. By analysing the design process of professionals and students, we have found that designers block out sustainability factors in the early stages of design, because of a preconceived view that the task is one of assessing product specification rather than framing creative opportunities. This preconceived view is influenced by the types of tools available, which are mainly focussed on assessment of a finished design rather than exploring what might be possible. In this paper we investigate how designers address complex and interrelated sustainability factors in early stages of design.

To support this investigation we created a web based 'soft modelling' tool (available at www.trophec.com), to enable designers to quickly visualise the impact of their early design decisions. Whilst we found that the tool helped designers interpret complex design problems from a sustainability perspective, they were only prepared to do this if short periods of reflection were built into early stages of the process (by an external agent).

Keywords: sustainable design, circular economy, soft modelling, life cycle, interdependencies.

1 CONTEXT

Several design practitioners and researchers have proposed general frameworks that support the notion of good design and also propose a sustainability point of view (Benyus, 2002; Datschefski, 2001; Hawken, Lovins, & Lovins, 1999; Living-Principles, 2014; NCS, 2014; PLI, 2014; SROI-Network, 2014; Step, 2014). A detailed analysis of each one represents an endeavour beyond the goals and scope of this paper. Nevertheless, Shedroff (2009, p. 3) summarises it very clearly: "One serious problem for designers is that, even with a systems approach, there are few tools in existence that wrap these issues together. Instead, designers must learn to match together a series of disparate approaches, understandings, and frameworks in order to build a complete solution".

Furthermore, Brezel and van Hemel (1997) proposed a scale for the level of intervention in new product development depending on their sustainability impact, in incremental order:

- Product improvement (incremental innovation - low impact)
- Product redesign
- Function innovation
- System Innovation (higher impact)

Other researchers have proposed this scale in similar terms (Thackara, 2005; Vezzoli & Manzini, 2008).

The impact of integrating environmental requirements is higher in early stages of design (T. A. Bhamra et al., 1999; EuropeanComission, 2012; Lindahl, 2005; Matzke, Corky Chew, & Wu, 1998; Ritzen, 2000; Sherwin, 2000), when the problem is first stated (sometimes in the form of a brief), and the product strategy is defined. This is the point where the information to solve it, if it is not already available, must also be acquired (V Goel & Pirolli, 1989).

Similarly Fabrycky (1987) found that over 70% of the final product is directly influenced from design stages. These notions have also been discussed by other researchers (Andreasen & Hein, 1987; Burall, 1996; McAloone & Evans, 1997). The further a product advances in the development process, the more decisions are made (V Goel & Pirolli, 1989) and consequently the more difficult it becomes to make systemic changes (Brezet & van Hemel, 1997). On the other hand, the assessment of sustainability issues in a defined design can only result in incremental improvements, which is unlikely to lead to fundamentally sustainable development (McDonough & Braungart, 2001).

Most of the available tools, methods and guidelines do not seem to adequately address designers' working culture and characteristics at the fuzzy front end of design. Vallet et al. (2013) tested three different eco-design tools: Simapro, Ecofaire and Ecodesign Pilot, which the authors selected as representatives of the eco-design tool classification categories proposed by Knight and Jenkins (2009).

Their findings indicate the lack of relevance of these tools at early stages of design, with the authors declaring that environmental assessment and strategy definition has more influence by expertise than the use of tools. This in turn may invoke fixation and a predetermined mental set (Sternberg, 2003), probably caused by their experience (Purcell & Gero, 2006) in the form of a 'pre-analytic vision' (Schumpeter, 1954). Another probable cause for fixation might be related to the type of 'external stimulus' these tools represent to designers, and may not apply adequately in the level of abstraction and transformation found by Goldschmidt (2011).

The possibility of fixation in relation to environmental information as a deterrent for creativity, as well as the level of detail of this information, has also been studied by Collado and Ostad (2010). Their first findings were the barriers for the internalisation of principles, barriers that encourage most companies to ignore any eco-design method: complexity of implementation, need for specific training and the scope of solutions proposed.

Collado and Ostad (2010) conclude that: 'information must be available, but fixation avoided'. Finally they define 'soft information' as the most appropriate for designers.

Lastly Ostad et al. (2011) surveyed 11 design experts on their requirements for eco-design tools in 4 key aspects:

- Information
- Motivation
- Multidisciplinary cooperation
- Creative environments

Their findings can be summarised as follows: the main driver is environmental concern and the main deterrent is additional workload. For designers, motivation is more important than cooperation and information, but they saw these last factors as mostly needed. Incompatibility of tools with the product development process seems to be the main reason for not using them.

Among other things the participants declared that eco-design is an additional process to the general design conception. The researchers therefore recommend that organisations:

- Provide information as necessary in the design process
- Avoid excessive information and data flow
- Clearly show how design activities influence the sustainability performance of the product
- Allow information sharing between different departments
- Avoid excessive involvement of designers with the tool
- Assist the engineer designer in all design phases

More tool characteristics have been identified; Lofthouse (2006) found in an 18-months long research project, that eco-design tools fail because they do not address the design function. Rather they guide strategic management or existing product's retrospective analysis.

Lastly Bovea and Perez (2012) found that although the diversity of tools for integrating environmental aspects in new product development is wide, in real-life scenarios they are scarcely implemented.

2 SOFT MODELLING

The Oxford Dictionary (2014) defines 'model' as: 'a simplified description, especially a mathematical one, of a system or process, to assist calculation and predictions. The terms 'hard' or 'soft' are some times added when the model being built considers all factors and possibilities in a deterministic fashion for the former, or a more simplified and holistic approach is taken in order to gain speed and a broader perspective for the latter, this is particularly useful when the researcher

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faces more qualitative than quantitative information, or when there is no 'solid ground' where to start as is often the case in Social Sciences (Hartmann, 1996).

Falk & Miller (1992) note Professor Herman Wold as the developer of a soft mathematical and statistical model for the social sciences, where the model 'is soft in the sense that it makes no measurement, distributional, or sample size assumptions'. They explain further: 'as an aid to researchers, soft modelling provides a system for expressing theoretical ideas about a sequence of events. It can be thought of as a tool for assessing ideas by relating theoretical interest to observations of the world as experienced'.

Therefore, the approach was to use a 'soft modelling' system, with the goal of creating 'the optimal linear predictive relationships among variables', not a final statement of causality (Falk & Miller 1992). In other words we seek to highlight the connections and interdependencies among the life cycle steps of any given product in order for the designer to make more informed decisions.

3 INVESTIGATION

In light of the findings of a literature review, the researchers designed a soft modelling tool that attempts to incorporate the recommendations of the above mentioned researchers, in order to address sustainability issues in early stages of design and in resonance to the particular characteristics of designers' working culture in such moments. The tool, which was named 'Trophec', was built as an online software with free access, it provided one screen only with five main steps of the product life cycle:
1 .- Materials
2 .- Manufacturing
3 .- Transportation
4 .- Usage
5 .- End of life

All steps and options were visually represented with pictograms and colour coded. Basic calculations showed the impact in terms of CO_2 production, Energy usage, and material intensity of air, water and solid matter; as well as infographics related to complementary themes like: biodiversity, child labour, demographics, energy generation sources, etc. It can be found at: www.trophec.com

Therefore, our research question was: *How is the designer's working process influenced or altered when sustainability-related information is presented in early stages of new product development, through means of an online "soft modelling" software (Trophec)?*

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In order to find if such influences occurred or not, we conducted a series of experimental design sessions. One pilot test was conducted with 13 sets, each consisting of three undergraduate students. The first test involved nine students studying on a graduate design program, and organised into three sets of three participants. The second test involved six professional industrial designers working individually. The protocol was based on the think aloud method (van Someren, Barnard, & Sandberg, 1994), therefore the sessions were video recorded by a camera focussed on the computer screen and the working area in front of the designers, in order to register their sketch creation sequence and other events.

The test involved solving a design brief that the researches sourced from a NESTA design contest (NESTA, 2013). The brief asked the designers to address the problem of bicycles being stolen, and emphasised the aim that 'the winning innovation will be the one that requires the longest time to steal the bike'. There were three other criteria: impact on the environment, cost to buy or implement and implementation, and adoption at scale through commercialisation and other means.

The test lasted 110 minutes. First the participants where introduced to the test and the soft modelling tool, by viewing three videos explaining the purpose and the detailed use of the tool. After viewing the videos ten minutes was allocated for familiarisation. Immediately after the test took place without any further instructions or interventions by the researchers.

On the pilot test (undergraduate students), the 13 sets were divided into three groups, one acted as control group without the soft modelling tool or any information given by the researchers (four sets), the second one, also control group working under the same conditions but were provided with a paper sheet with the web addresses of all the sources the soft modelling tool uses for its calculations, this was denominated as 'raw data sources' (four sets). The third group worked with the conditions described above (five sets).

As a result of the pilot session, in the subsequent tests the process was divided in three sections, each lasting 30 minutes:

1 .- Conceptualisation
2 .- Refinement
3 .- Definition

These sections represented three sequential steps of the design process according to the work of Self (2011), in which the 'early stages' and 'final stages' could be distinguished. Between steps one and two, and two and three, a period of ten minutes was allocated for the use of the tool. All participants had at all times free access to a computer and Internet. At the end of the test participants took part in an unstructured interview.

In the first test (graduate students), set one performed the test with the exact same conditions as set three of the pilot test, that is, the tool was introduced, but the process was not divided and no further instructions or interventions by the researches took place. Sets two and three worked with the process divided as described above.

In the second test (professional designers, each working in their own office), they all worked with the process divided in three sections, the only difference was in the first two participants, where the period to use the tool was allocated but it was left optional, and in the other four the use was compulsory.

4 ANALYSIS

In the pilot test there were no significant differences between control and experimental sets. Control group with the 'raw data sources' made no use of it at all. The sets that did use the tool, did so in the last minutes of the test, and only when they had a product defined. These results informed the researches of the need for allocating time to use the tool, as well as pauses in the process that allowed for reflection.

In test one, just like in the pilot test, set one made no use of the tool at all, they had a very long initial period of information research and conceptualisation, and by the end of the test they had to rush to give a final proposal, which they did not achieved. In the final minutes each student worked individually and no final idea was proposed. Professionals one and two also decided not to use the tool, and furthermore, declared that there was no need to go into refinement or definition.

All other sets and professional designers used the tool as planned; all of them proceeded voluntarily to build a cycle, even if sometimes there was no specific product to input in the system. This did not seem to be a problem, with some of them declaring the exercise to be just a great assumption, or just making wild guesses, they all finished and in many cases important phenomena was observed.

Throughout all the sessions it was clearly evident that students focused almost exclusively in the functionality of the proposals, leaving almost all other three criteria as secondary or not even considered. Professionals using the tool focused more on environmental issues (shown as impact on figure 1), and professionals one and two focused more on implementation and costs, figure 1.

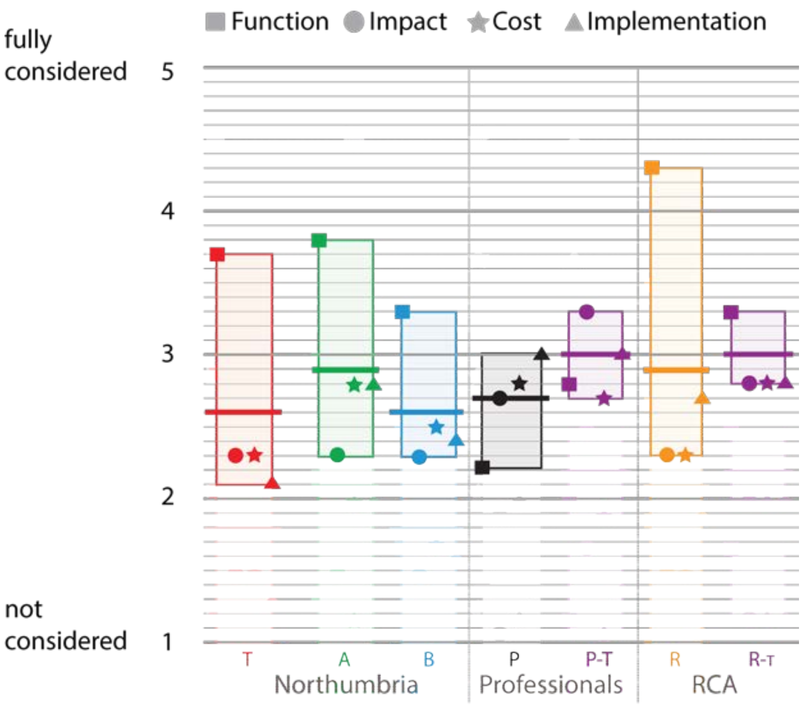

Fig. 1 Average per brief criteria.

Three independent researchers graded independently all sets' proposals regarding the four criteria contained in the brief. 'One' was assigned when no considerations at all were made, up to 'five' when the criteria was fully considered. Each point in the coloured blocks represents one criterion, all in the next order: Function, Impact, Cost and Implementation. In the graphic 'T', 'A' and 'B' belong to the pilot test, where 'T' is the experimental group, 'A' control, 'B' control with 'raw data source'. 'P' stands for professionals who did not use the tool. 'P-T' professionals that made use of the tool. 'R' is set one of graduate students, which followed the same protocol than 'T' sets in the pilot test. 'R-T' graduate students that made use of the tool.

Whilst both students and professionals demonstrated that they were aware of the tool, had previously tested it and were given the option of using it, they did not so on any occasion. From this we draw the conclusion that under these controlled conditions designer's willingness to engage with sustainability criteria in the early stages of the design process depends on their individual skills, awareness and knowledge. This is reinforced by statements made later in the interviews, where participants declared that sustainability criteria were things to be added 'later', once the object is defined. We found that designers tend to consider sustainability not as part of their understanding of the design problem but as criteria against which to judge their final design solution.

All major influences detected happened between steps one and two, which is consistent with the idea that it is more feasible to include sustainability criteria in early stages and the impact of doing so is greater. The main clear influences happened with professional designers and were detected through the verbalisations of the think-aloud method.

Before the first use of the tool (in step one), PRO4 had already envisioned some recycling strategies specially developed as part of his product's life cycle. When checking the materials' characteristics he realised the impossibility of his assumptions, as is clearly demonstrated in his statement: 'because of ignorance, what you do here is not necessarily the best option'. The experience of these 'connections' within a cycle, encouraged PRO4 to reflect deeply about the possibility of combining the life cycle of diverse products, this ultimately led him to produce two cycles of complementary products in the second use of the tool.

PRO5 had a similar experience. Before the first use of the tool he had a well-developed idea, which included some materials selection, one of them involved the use of concrete, for the base of his parking system. When analysing the material characteristic with Trophec, and considering how the product's life would end, he realised that concrete is not recyclable or reusable, and therefore decided to change his choice of material. He came to the conclusion that for this application wood, with proper maintenance, could be as strong and last as long as concrete. This change did not affect the design embodiment he was working on; the form and function remained exactly the same.

During the first stage of the test PRO6 developed several concepts, he considered the materials characteristics and settled on a recycling strategy. When starting the second step of the design process, he stated that the Trophec tool 'gave him a lot' in order to focus his work, and proceeded to select one of the concepts he had generated to work with for the rest of the test, declaring that it was the one fitting best his sustainability target.

There appears to be no impact or influence directly related to the use of the tool in any of the analysed elements of the designers' working process. The number of sketches produced did not changed, neither did the time taken to create them or the connections between them. Dialogue continued in same amount and duration and no relationship was observed between the appearance of lateral transformations (V. Goel, 1995) or new concept creations. The authors interpret this as a positive signal of no hindrance from the tool for the normal working process, as no blockage or fixation caused by the tool was observed. All influences were detected in participant's verbalisations, when clear broad decisions and reflections were being made, resulting from the use of the tool

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5 Interviews

The opportunity of having several professional designers involved with this research was maximised by ending each session with an unstructured interview. The interview questions addressed the conditions they faced in practice when dealing with the incorporation of sustainability criteria in their projects. The responses were enlightening. PRO1 and PRO2, for whom the use of the tool was optional and who decided not to use it, made comments relating to the perception of sustainability as something to add later (just like graduate students), supporting the idea that designers, not only students, but professionals too, see the incorporation of sustainability factors as an assessment to perform late in the process, rather than an early aid to build design concepts.

Beyond that, the most powerful declarations related to the fact that many decisions affecting the design are not taken by designers at all, with the design brief normally drafted by management or marketing departments. Some decisions that could make the product more sustainable are related to the business model, in which, almost all designers agreed they have no input. This is in line with findings of previous research (Baynes, 2001; Deutz, McGuire, & Neighbour, 2013; Sherwin, 2000). The only exception came from PRO3 and PRO4, who have been involved with start-ups, and who declared that in the case of small new business, they do have the chance to intervene.

Furthermore, they accepted that they do not consider sustainability because there is no demand. Their clients or employers normally see sustainability as extra cost and extra time, and do not request it. Lastly, many of them agree that companies' processes are divided in different departments and that designers rarely get the chance to influence them. Because these departments are almost never connected, and work in 'silos' there is no one, not even in management, who has the overview and control of the entire process. Therefore, the realm of influence of designers is greatly limited. Sustainability, some of them declared, must start within the company's culture. In this respect our findings align with the work of Johansson (2002) and Bhamra & Lofthouse (2007).

The above also supports the idea that the macro-economic model and in many cases society in general, influences the culture and performance of companies, ultimately dictating what is commonly requested and expected from designers. Many of these choices are typically made not by designers, but by other stakeholders in the process (e.g. marketing and management).

One last outstanding opportunity for this research took place shortly after the tests were carried out. Dr. Chris Sherwin, who's work has been cited previously, was contacted and agreed to be interviewed, (he also granted permission to be mentioned in this research). Dr. Sherwin is Head of Sustainability at,

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internationally renowned design consultancy Seymourpowell, and the research mentioned in this paper is his PhD thesis completed in 2000. Here he makes a number of fundamental findings related to eco-design and its practical application by professionals. Importantly Dr. Sherwin mentions that today almost half his work is dedicated to 'demand-creation': trying to get clients to include sustainability criteria in their projects. This is not always successful, and depends on there being a corporate sustainability mandate or a strong business case.

In 2000, Dr. Sherwin found that eco-design was *'not connected to design at all'*, it was reduced to just *'technical dimensions'*. Furthermore, recognising the limited capacity of designers to influence all the design process, he stated that design should *'stretch and extend its own competencies'*. When asked about the advances achieved in these last 14 years, he said that designers definitely *'are not at the leading edge of sustainability'*, that even if some progress has been made, it is dominated by *'creeping incrementalism'* and *'business-as-usual'*. He sees only two exceptions: *'clean tech movement'* (renewable energy, green chemistry, eco-transport options etc. in which designers are scarcely involved), and *'social innovation'*, where *'entrepreneurs work outside the formal structures/drivers of capitalist economies'* and where designers have had some important successes.

Nevertheless, he adds that *'consumers won't drive the sustainability revolution'*, and closes by saying: *'We need to extend our approaches from only focussing on the 'consumer/customer journey' and touch points, to all the aspects of the 'product journey', both upstream issues like sourcing, transport and manufacturing, and downstream issues like disposal, recycling and reuse. I don't think we are anywhere near training designers to do that and I still see lots of designers thinking they can deliver sustainability successfully with these old-fashioned human-centred design processes. We won't.'*

6 CONCLUSIONS

The findings of this research project sadly show that despite a large body of knowledge designers' engagement with sustainability factors has developed little over the last 14 years since Sherwin's study (2000), however the key to a fundamental change in approach does not reside solely with designers. Focus on whole systems design, which could finally facilitate the 'integration' of the *'product journey'*, is still in its infancy and requires much more attention (Charnley & Lemon, 2010).

Whilst designers play only a small part in creating a more sustainable world, design thinking methods that encourage a whole process view of manufacture, can offer soft modelling approaches that are relevant and applicable across a wide range of disciplines. We found that the soft modelling tool tested in this research helped to achieve improvements in designers' working process that influenced the 'technical dimension' of their output. Because of its focus on the early stages of

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product development, soft modelling could be seen as an opportunity to assist integration, highlighting interdependencies and interconnectivities in a product's life cycle among the different departments within a company.

The use of relational and systems thinking tools to facilitate sustainable design throughout business and society, could prove to be far more valuable and effective, than focussing responsibility for our future with designers.

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