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Can Design-Driven Material Innovation also drive circularity?

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ABSTRACT

Design-Driven Material Innovation is espoused as a win-win solution, for consumers, economies and circularity. However, there is little empirical research on its methods or outcomes. This paper presents the results of an ethnographic study that examined the first phases of a design-driven project in the field of textile fibre development.

KEY WORDS

Design-Driven Innovation; fibre development; Design for a Circular Economy; recycling; ethnography

INTRODUCTION

The resource intensity of the textile industry presents a pressing problem, exacerbated by overconsumption in Western countries and increased demand in emerging economies because of rising standards of living. Cotton, the most popular natural fibre, entails significant environmental and social problems, and polyester is petroleum oil-based. At the same time there is no efficient way of recycling these materials. There is a clear need for technological development related to recycling (Zamani et al. 2015).

But developing recycled and/or recyclable materials is not the only demand material developers are facing today. There is also increased emphasis to develop materials that increase the competitive advantage of European industries, meeting the needs of users and manufacturers (European Commission 2013a; 2013b). Integrating designers into early stages of material development has been suggested as one potential solution to these challenges, an approach sometimes referred to as Design Driven Material Innovation (DDMI). Recent research on material innovation processes, especially in the context of nanomaterials, also recommends adopting novel approaches (e.g. Linton and Walsh 2008).

Developing purposeful and commercially viable materials need not be limited to those produced from virgin resources; design-driven innovation can also be a tool in the development of materials for a circular economy. It even appears that a design-driven approach and developing systems for a circular economy have potential synergy, since they both require collaborative efforts targeted towards a material future. This study investigates the relationship of these two approaches through a project where designers and material scientists work together with market experts and the manufacturing industry to develop novel textile fibres from waste using chemical recycling.

BACKGROUND

Recycling textile waste by developing new fibres and thereby higher value products is preferable to current practices, where much textile waste in Europe goes to landfill or to energy recovery (Zamani et al. 2015; Wang 2010). Increasingly, textiles and other materials are recycled into carpets, insulation materials, automotive components and other applications (Wang 2010; Valverde et al. 2013).

Such recycling processes can be made even more eco-efficient if the design phase considers recycling, remanufacturing and material recovery from the outset (Muthu et al. 2012). The emerging concept of Design for a Circular Economy (DCE) encompasses 'Design for X' practices that support circularity. The RSA's Great Recovery initiative, for example, has presented four design models or principles (RSA 2016) (Figure 1).



Figure 1: The Four Models of DCE (Source: RSA Great Recovery, used with permission.)

Furthermore, products and solutions could be developed that are novel and attractive to consumers: the principle behind Design-Driven Innovation (DDI) and Design-Driven Material Innovation (DDMI). While there are few academic studies on DDI,¹ its body of discourse in both policy and consultancy arenas is growing. This discourse is currently mainly divided into two branches. In the context of products, DDI as "innovation of meaning" is the most well-known approach, where developing appealing products creates new markets, in contrast to meeting current market needs (Verganti 2009). The second branch relates to European Commission policy and funding tools, where DDI is seen as a valuable strategy to increase European competitiveness (European Commission 2013a; European Design Innovation Initiative 2012). The aim is to enhance "European SMEs' ability to use design as a strategic tool in creating products and services with a higher value for their customers" (European Commission 2013a). Both branches endorse design being brought earlier into the value chain than is conventional.

The main focus in both DDI branches is on economic benefit and added value, but the EC's Horizon2020 Research and Innovation programme that funded the project studied here also highlights increased environmental sustainability as an explicit objective: funded projects should employ a DDI approach in order to strengthen creative industries by developing new materials from waste or by-products and new products with lower environmental footprint (European Commission 2013b). Verganti himself (2010) has also claimed the superiority of design-driven approaches to meet sustainability goals. However, the empirics of how design of this kind can contribute to circularity have been little articulated,² the actual tools and methods in DDI are neither widely known nor codified, and the inevitable trade-offs encountered in such processes are easily hidden by policy rhetoric.

How the DDI focus on added value encounters circularity ambitions requires careful examination. Our research question in this paper is the following: *does the adoption of a design-driven innovation process appear to help or hinder circularity-oriented material development processes?*

In this study we concentrate on the first phase of the project. We focus on the project workshops, the main means for working together where otherwise geographically dispersed participants (usually about 30 people) meet face-to-face. The workshops provide the primary platform for collaborative project work and decision-making. We present our data and methods in the next section, followed by the key findings.

¹ the body of literature on DDMI is scarce and strongly reflects the discussion on DDI

² including what may be important differences between material development and product development

METHODS

This study is based on data gathered with ethnographic methods in the first nine months of the project, entailing the first three workshops. The data set includes fieldnotes (8 sets), photographs (1240) and audio (32 hours) and video recordings (21 hours) taken by the first two authors as participant observers, as well as workshop materials such as presentations, worksheets, agendas and minutes. The various data materials were summarised in notes, and portions of the recordings seen as important were transcribed, those incidents conveying conflict, confusion, facilitation etc. In collaborative analysis sessions, two themes of added value and circularity and the research question for this study were identified. Accordingly, the notes, fieldnotes and transcripts were coded by the first two authors independently using thematic analysis (Braun and Clarke 2006). The three authors then discussed the coded documents in several analysis sessions.

All three authors have worked in the project as participant observers, with varying proportions of participation and observation. The main workflow of the project has been planned by other participants, but we have contributed to workshop planning by participating in meetings and giving feedback prior to and after the workshops. Participation in these in-between-workshops activities has also provided insights into the process for the authors, but this information has not been used as primary data.

FINDINGS

In this phase of the project, the 'front end', the design-driven approach was actualised particularly in ideation (or envisioning) activities, such as brainstorming and scenario building. These activities were not carried out by designers alone but performed collectively in the workshops, an approach that was considered non-traditional by material scientists. In our observations, the designers appeared to push the boundaries of what was seen possible, to push the imagination and level of 'innovation' aspired to, while the manufacturing and technical experts tended to remind the others of realistic constraints. However, when the purpose of the 'high-flying' envisioning exercises was less clear to participants, and when the realistic 'grounding' in material circumstances was absent, some dismissed the scenario work as irrelevant to their own role and became disengaged.

Another insight relates to collaboration on goal setting and what arose as important for the participants. Added value as an objective was discussed throughout the project workshops, which is not surprising considering the design-driven nature of the project. The number and diversity of partnering organisations may also have contributed to the frequent discussion on what exactly this added value of recycled material should be, and for whom to add value. As a special case of customer value, the concept of quality was constantly on the table.³

D1 – *“If you accept that the fibre and material will be weaker than this extreme strength, you have other benefits, the softness of it, a low level of pilling. You might have this origin, it comes from somewhere, it might be authentic, you have this colouring and your clothes are different from others on the store shelf; in that case it might have a lower carbon footprint.”*

R&D1 – *“I guess for some products, people don't use them for so long, (...) [I]t doesn't matter if it looks good for only four washes, because some people maybe use it four or six times, (...) so I don't think high quality is important in all products.”*

D2 – *“There are some processes that don't take water when dyeing; it's not a matter of fibre, but just a process innovation (...) [I]n this case the benefit is not perceived by the end user, it's just a B2B benefit.”*

R&D2 – *“Bacteria very much likes to stay in this material more than on natural fibres for example. (...) (W)hen you take a shirt of polyester, after...”*

M1 – *“The smell (...) of polyester.”*

D2 – *“For anti-smell treatment or another kind of treatment, it's necessary to work on the fibres, or no?”*

R&D3 – *“It's really hard to work on the fibre level, you work on the fabric...”*

D2 – *“No, I mean, sorry, if I have to make an anti-smell treatment...”*

R&D2 – *“Fabric, fabric.”*

D2 – *“Just on the fabric. So it's not necessary to take the fibre into consideration?”*

R&D3 – *“It depends, for example if you want to have this kind of effect permanent, for example antibacterial or anti-stain, you can work on the fibre level. But if you just use spin finish, plasma-treatment, after washing, several washes...”*

D3 – *“It comes away.”*

³ In all quotes: D1, D2, D3 = designers; M1, M2 = manufacturing industry representatives; R&D1, R&D2, R&D3, R&D4, R&D5 = research and development experts, either in academia or a company

R&D3 – *“Yeah.”*

D3 – *“So is that a question for us, is there a benefit for the end-user to engineer it into the fibre?”*

(...)

R&D2 – *“There is one limitation, that is the cost. Treatment on fibre is also more than one degree of magnitude more expensive than on the fabric.”*

These excerpts illustrate not only the range of discussions on added value (for the end-user and the manufacturer), but also an almost constant challenge: it was not clear where certain properties should be added in the long value chain of fashion and textiles. As a result, the conversation bounced from the level of fibres to products, to fabric structure, to marketing, and back to fibres.

In addition, due to the aim of developing novel fibres from waste, circularity was explored through several lenses in the workshops. Challenges related to using recycled material were acknowledged, in sourcing, separation, recovery and consumer perception. Further recyclability of project outcomes, the required percentage of virgin material added into the loop and the possible number of recycling loops were mentioned several times. Especially the topic of dyes was frequently on the table, both in the context of current recycling practices and future needs:

R&D3 – *“It’s because they [a particular company] know what kind of pigment they dye the polyester with, so they know how to remove it easily. Also with spin finish and other finishes, it takes more energy to recycle if they don’t know what kind of finish is used. They will use more energy to recycle them, and it’s no longer an environmental process.”*

M2 – *“For eco-products, new dyes must be developed which can be removable.”*

However, instead of raising 'added value' issues and circularity issues as separate topics, they were most often discussed together and weighed against each other:

R&D2 – *“[I]f we want to have high quality and total recyclability, then we’re pushing too much towards what we cannot have.”*

D3 – *“This one that is blended has a longer life, but the problem is we have to recycle it. So we have to be conscious of the lifetime of the product we are making; there are benefits to keeping it pure, but also drawbacks.”*

R&D4 – *“We are speaking now of recyclability, and then it competes with topics of durability, quality expectations, reusability.”*

R&D5 – *“What I see here about this discussion is a lot about how to increase the value, so how to make it even better, really exciting, but our problem is we are actually starting from (...) the pile of waste.”*

(...)

“[T]hinking ahead for the next generation, instead of now devoting all our efforts in making new and better materials, it’s just the same materials but really intended for recycling, so that’s what I personally would like to see there on this board.”

M1 – *“I don’t see that a recyclable product will have some additional characteristic, something more. But the idea is a recyclable product and people would like recyclable products, because they care about the planet.”*

These excerpts show how potential trade-offs and challenges were acknowledged and discussed, particularly tensions between added value and material circularity, and product longevity and circularity. These trade-offs were not limited to technical issues or 'silos' such as 'cost' and 'benefit', but involved many issues across the value chain.

Moreover, over the timespan of the project phase we observed, the differing perspectives on goals, challenges and trade-offs were represented relatively equally in the discussions: no one perspective or set of interests clearly dominated. This appears to be due to the way the workshops were organised. Here, especially the manufacturing and technical experts were actively objecting if ideas drifted towards unrecyclable, unsustainable or unfeasible options. By the same token, technical research and development experts were exposed to end-consumer points of view that may not be represented in conventional material development; the majority of these comments were contributed by designers, manufacturing representatives or market experts. This study therefore emphasizes how such open discussions on trade-offs were fostered by the multi-professional interaction.

DISCUSSION

As seen in the previous section, a significant part of the project discussions focused on topics of added value, quality and circularity. Such a plurality of goals may be seen as one of the potential benefits of DDMI in the context of circularity. Sustainability issues can easily be overruled by other priorities as a project progresses, but in this project concerns about customer expectations, economic viability and sustainability were equally raised in discussion. Sometimes participants had differing views about potential conflicts or synergy between added value and technical feasibility. These differences may result from diverging perceptions on quality and added value. Some project participants seemed to regard high quality as a standard product feature, whereas others may have expected it to be something better than the majority of existing options. In future phases and future projects, clarifying different aspects of customer value, such as tangible and intangible value (European Commission 2013b), may open up some issues that now appear to be trade-offs, making them more amenable to evaluation and prioritisation.

The high occurrence of concepts like quality and recyclability also suggests that two different DCE models emerge as important for the project. Discussions around quality, customer value and extended product lifetime, probably stemming from the design-driven origin of the project, have been described in the literature as elements of Design for Longevity (cf. Page 2014; Van Nes and Cramer 2005). On the other hand, Design for Material Recovery is obviously linked to material recovery processes and making products recyclable (cf. Rose and Ishii 1999). The fact that added value and recyclability were most often discussed together can be seen as a signal that these models compete with each other, at least to a certain extent. Some literature is emerging about the applicability of different DCE models to different product areas, such as suggestions to use short-life, closed-loop items to complement more durable and classic products (Earley and Goldsworthy 2015). Once the project proceeds, either a choice between these models needs to be made, or their compatibility needs to be solved. The latter possibility shows how DDMI has innovative potential in the context of a circular economy. As was raised in the workshop discussions, there are indeed some real-life challenges in making high quality products out of waste (the mid-grey arrow in Figure 2), at least in the field of fashion and textiles. And similarly, when designing products primarily for long life, for example by using blends and additional finishes, one will eventually have to deal with the recovery of these products at the end of their life (the darkest grey arrow in Figure 2).

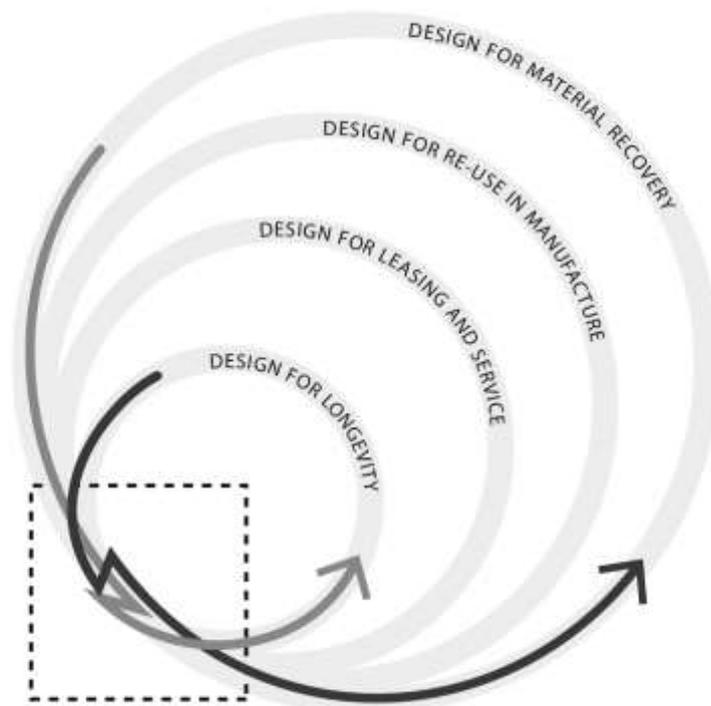


Figure 2: Challenges in reconciling two DCE models, as discussed in the project. Adapted from The Four Design Models (RSA 2016).

CONCLUSIONS

This paper contributes to existing literature by opening up the potential challenges and benefits of the Design Driven Material Innovation approach by observing what actually happens in such a process. Zooming into a particular context of DDMI work enables the evaluation of these challenges and benefits with respect to expected outcomes, in this case circularity of textiles. The results of this study suggest that a plurality of goals can prevent sustainability or end-user points of view being forgotten in the flow of the process. The design-driven approach can also contribute to circular solution development by enabling the recognition of important trade-offs early in the process. It can increase the discussion between different professional fields through more activities that are collaborative and 'visionary'. At the same time, more attention needs to be paid to communicating the meaning of these activities to all partners. If the aim of activities that are targeted outside participants' own professional area remain unclear, people are at risk of becoming disengaged. These results come from the early stage of the project, and the researchers will continue to observe the process to clarify their findings and contribute to academic knowledge about DDMI processes.

This study also pointed out topics for future research. For example, the vast amount of discussion about dyes and colour has already made clear that further research on this topic, from consumer, manufacturer and material recovery points of view, is needed. The dialogue on quality and recyclability showed that it is an opportune time for a richer discussion on the different design models for a circular economy, especially the ones focusing on product longevity and recyclability. It is not yet clear how these models are connected. Will these design models run in parallel in our fashion system, rather than integrated, and will they also contribute to different material cycles? Or can DDMI actually function as a tool for bringing these approaches together? Further discussion on these topics would help both material developers and designers to understand the actual professional challenges they will face when entering the era of a circular economy.

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