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Published in:
Design for Next

DOI:
10.1080/14606925.2017.1352940

Published: 12/04/2017

Document Version
Publisher's PDF, also known as Version of record

Please cite the original version:
Niinimäki, K., Tanttu, M., & Kohtala, C. (2017). Outside the "Comfort Zone": Designing Unknown in a Multidisciplinary Setting. In L. Di Lucchio, L. Imbesi, & P. Atkinson (Eds.), Design for Next: Proceedings of the 12th European Academy of Design Conference (The Design Journal; Vol. 20, No. Supplement 1). https://doi.org/10.1080/14606925.2017.1352940

Design for Next

12th EAD Conference
Sapienza University of Rome
12-14 April 2017

Outside the "Comfort Zone". Designing the Unknown in a Multidisciplinary Setting

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Abstract: This paper presents a case study where the early stage of multidisciplinary collaboration is investigated. In the studied case designers work together with material scientists, market experts and the manufacturing industry to develop new textile fibres from waste using novel innovations in chemical recycling. The studied project is defined to be design-driven, and it aims at material innovation through multidisciplinary collaboration. This paper focuses on the first round, the initiative stage where different disciplines learn to collaborate and where the "unknown" is designed: the attributes for the future material. The data covers the first 12-month period in the project and meetings, workshops and communications in the project during this time. The participant observation approach is used. The results show that multidisciplinary collaboration needs participants' readiness to step outside the practices of their discipline and learn collaboration. Further knowledge intermediators are needed for bridging knowledge gaps between different disciplines.

Keywords: Design-driven, Multidisciplinary, Innovation, Material Innovation

1. Introduction

DDMI, Design-driven material innovation, is a novel process, and it challenges the designer's role, knowledge base and way of working. Traditionally the material and its attributes are known when the design process starts. A material-driven NPD (New Product Design) process is based on this approach, and a new product and its functions can be designed based on known material attributes. On the other hand NPD can start from the product idea and materials are selected to best suit the target product's functions. In the current case designers have to dive much deeper and step outside their comfort zone and knowledge area to understand material researchers and their challenges in the material development process. This approach creates new challenges in the design process and extends the current understanding of design thinking.

A suitable and novel design thinking approach needs to be constructed to solve this new design problem, when aiming for a Design-Driven Material Innovation DDMI process. Verganti (2009) has laid the grounds for Design-driven Innovation (DDI) understanding, but from an innovation management viewpoint. He focuses on the creation of meaning in a NPD process, where developing appealing products creates new markets, in contrast to meeting current market needs. This is still a very market-oriented approach and not suitable for the current project in a material innovation process. On the other hand the design thinking approach has gained popularity and is proposed to be suitable for all kinds of problem solving, especially so while developing new innovative solutions using flexible and explorative activities (e.g. Kimbell 2011; Brown 2008, 2009). Yet design thinking as a defined method is still evolving, and new knowledge is needed to understand complex multidisciplinary processes while integrating them with the design thinking approach, as is the case in this study on design-driven material innovation.

Earlier studies have shown that the innovation process is challenging. Especially it is hard to share knowledge in the innovation process (Smulders & Bakker, 2012). Boundary objects (Star & Griesemer, 1989 cited by Stompff, G. & Smulders, F. 2015) can help as they serve to transform knowledge across barriers (e.g. Carlie, 2002, 2004), and these are especially valuable in NPD process (e.g. Bechky, 2003). Carlie (2002, 2004) has identified e.g. methods, models and maps as boundary objects, which can help the shared understanding to happen. Boundary objects "sit amidst all practices" meaning that one can be "placed" between different disciplinary practices. Yet it is also integrated in some level into different disciplines and can act as a node, and therefore it can transform knowledge between disciplines (Star & Griesemer, 1989 cited by Stompff, G. & Smulders, F. 2015).

Recently scholars have been proposing that in NPD processes designers should expand their roles and designers should lead and strongly support the whole process (Perks et al. 2005). Moreover e.g. Turner (2003) proposes that designers take roles like interpreter, coordinator and facilitator in an NPD process. The designer's role is shifting, also in the textile material field as in the current case. Yet only a limited amount of knowledge exists based on empirical research, which could show the dynamics in and explain this emerging phenomena of using the design-driven approach in multidisciplinary collaboration. Can the designer be in all cases the facilitator who enables different disciplines to work together? Or does co-learning happen at a deeper level with the help of design thinking and through design methods? Is the designer's skillset and understanding enough when aiming for material innovation? How to overcome obstacles in multidisciplinary collaboration? Are boundary objects enough in this process?

Ordonez et al. (2012, 7) argued that in the case where a new product is designed from waste material the current knowledge from the NPD process is not sufficient. They argue that more up-front activities are needed, when "the design objectives are too vague in relation to objectives of traditional product design". This is also true in a research and development project that uses textile waste to develop new fibres by using novel innovations in chemical recycling. In the current case the unknown areas are the future material attributes, products and application areas as well as knowledge from the end markets and trends.

“How can we design anything if the material properties are unknown,” was pointed out by a designer during the first official project starting meeting in the EU in Brussels, June 2015. This question can be seen as the main challenge in this research and development project, especially how to design future material attributes and material innovation in a multidisciplinary setting. We argue that the existing knowledge is not enough if aiming for unknown material innovations. Such an unknown material innovation process is based on future innovation approach, which according to Stompff and Smulders (2015) needs new framing and further study. Moreover new design thinking, understanding and methods are needed in this kind of unknown process. Therefore new knowledge needs to be constructed, which is based on empirical data from a material innovation process.

2. Research Objectives and Methodology

This study aims to empirically explore the nature of multidisciplinary collaboration in a research and development project, which aims at design-driven material innovation. The project consists of 18 stakeholders from ten countries. In the studied case designers work together with material scientists, with market experts and with the manufacturing industry to develop new textile fibres from waste using novel chemical recycling processes.

The specific research objectives are to identify 1) the process flow through a design-driven approach, and 2) attributes and elements which enable or hinder the innovation process in the early stage of the project. A case study methodology was adopted. Case study research is particularly suitable while aiming to study emerging phenomena whose dimensions are not yet fully understood (Yin, 2003).

The research uses the method of participant observation. The data has been collected during the first 12 months of the project. It consists of videos, audios, and field notes from meetings, workshops and communications (e-mails and skype calls) during the first year, which resulted in constructing the first design brief for future material attributes. In addition the data consists of questionnaires which were sent to all participants after workshops to map partners’ opinions about workshop activities and improvement proposals for the next workshop.

Descriptive analysis has been used to construct themes for this study. Four researchers have had several iterative analysis sessions throughout the first 12 months to build understanding of the project’s general flow, over workshop activities and their impact. There was an equitable division of responsibilities amongst the research team. Two of the researchers were in charge of data collection and its subsequent transcription. The other two were actively involved in both facilitating and participating in the workshop activities. These varying levels of participation also contribute to different levels of understanding.

3. Results

3.1 Process flow

In the studied case the whole project flow is organised around shared workshops which replace conventional project meetings. Four times a year all representatives of project stakeholders, around 30-35 participants, meet and work together with specific topics and tasks in a creative and design-driven way. In the early stage of the process, the topics have been 1) mapping interesting material properties for future materials, 2) building scenarios for new material properties in suitable use contexts, 3) trying to understand framings, technical possibilities and limitations.

The first year's workshop themes have been the following:

WS01 - KICK-OFF – KNOWLEDGE SHARING

- Starting to understand the project and getting to know each other.

WS02 – CYCLE A, DESIGN CYCLE, STEP 1 – ANALYSE POTENTIALITIES

- Painting the landscape, opening opportunities, ideation.

WS03 – CYCLE A, DESIGN CYCLE, STEP 2 – DEFINE NEW REQUIREMENTS

- Narrowing down, bringing in realities.

WS04 - CYCLE A, DESIGN CYCLE, STEP 3 – DEVELOP SOLUTIONS

- Laying the ground for the first design brief; selecting/narrowing, defining material properties suitable for different scenarios.

Designers who work in the project have done most of the work in planning and facilitating the workshops. As a result, the activities have remained closer to the comfort zone of designers than that of material scientists. Several requests, written down in feedback questionnaires, of adding presentations and clarifying the goal of creative activities can be a signal of having pushed material scientists far outside their professional practices and their own comfort zone.

Between the main workshops, smaller, local workshops have been organised, where designers, material scientists and industry representatives of just one country have worked intensively together to build shared understanding through design-driven methods and to get a deeper understanding of each field. In these sessions, e.g. the understanding of industries' strategic work in the material field is grounded. Furthermore several meetings between designers and material scientists have been organised to understand the material development process. Further meetings between designers have been carried out to develop the design-driven methods and activities.

The process has been iterative including widening of the scope with new ideas and thereafter narrowing the scope through selecting focus areas. Several boundary moments have been identified, which will be described in the following section.

3.2 Boundaries observed in the process

In teamwork members of the team often know each other and work well together. They have previous experience of collaboration or they present a knowledge area that is familiar to all team members. However the situation is different in a new project with multidisciplinary team members who might have difficulties in understanding each other or differences in disciplinary practices. Especially new is this kind of “teaming” between material scientists and designers in the textile field. Stompff and Smulders (2013, 148) point out that team members can experience boundaries at any point in time: in the early stage of ideation and imagining, in felt demarcations between specialists, departments or functional units. Furthermore they point out that specialist team members might have trouble making sense of each other’s “messages, situations and challenges” (ibid.)

The following boundary moments and aspects have been identified in the studied case.

Design-driven process

Design-driven processes and creative practices have not been familiar to all participants. “Why we are doing this activity” has been a comment we have heard many times during the workshop or after the sessions.

Quote from a WS03 feedback survey: *“From a scientists’ perspective, the topics in this workshop felt quite repetitive. I could not really understand if there was a difference between megatrends, scenarios, etc. In my opinion, it would be really helpful, if those people who actually work with the output from the workshop could explain how they use the obtained information in order to make things clearer.”*

Explaining to participants before the session the goals of the activity and its connection to the goals of the project would have helped participants to be motivated to join the action. This explanation cannot be clear or detailed enough: if this link between activity and learning outcome is missing, participants’ motivation decreases easily. Designers’ way of opening wider perspectives through collaborative imagination has been quite challenging to other disciplines. Designers also try to keep the process open as long as possible to collect all the ideas and not to limit the concept development phase too soon. This approach has confused some participants who have been wondering why the process is not proceeding or why the technical limitations are not included in the discussion “early enough”. Furthermore participants who are not familiar with design processes have wondered why critical discussion is not included in the brainstorming session (e.g. technical limitations). The following discussion happened during a brainstorming sessions, which was instructed to be free from limitations, a sort of a “dream island”.

> *“A (Designer)–Can I say something. In the brainstorming we have to understand if an idea could be empowered.*
> *B (R&D Specialist) –The question is price…*
> *A (interrupting)–Yea, but we don’t have the problem of price now…*
> *B (also interrupting)–Ok, I don’t speak more, excuse me.*
> *A: No no no, what I mean is that it could be a choice to produce something that is more expensive, we have had an idea to understand if it makes sense…*
> *(A and B continue speaking on top of each other)”*

Engaging in or disengaging from activities

In the first project cycle the workshops have based on creative activities. Some moments can be identified where these creative actions have caused disengagement. It has been easy to notice how in some stages e.g. material scientists feel unmotivated to participate in creative practices and are stepping out from the working process. Also situations where the group discussions have included only a few voices easily unmotivate other partners and therefore side activities happen.

Building a shared language

A shared language needs to be created in multidisciplinary collaboration. The meaning of terms like fractionation, dissolution and regeneration were unclear to many designers or industry partners. Similarly, basic textile concepts, such as nonwoven or filament were used vaguely, e.g. by those who have a background in chemistry, marketing or industrial design. On the other hand, some confusion was created through words that carry different meanings in different fields. What a person is referring to by using words like prototype, concept or spinning highly depends on his/her background.

Different tempos in the paths of development

It has taken quite a long time to understand that the current project include two different tempos; the material development advances more slowly than the design concept process. Two tempos have caused a lot of discussion and critical comments especially in the third and fourth quarter of the project. This has been obvious especially in the steering group meetings, and this discussion is still going on.

Setting the goal

Different disciplines have had different understandings of the project’s goal. One boundary moment was when a material scientist was wondering why designers cannot wait for the scientists to solve the technical feasibility and sustainability issues before ideating “how to make it [material attributes] even better”. From designer’s point of view influencing material properties already early on in the process is exactly the aim of design-driven material innovation process. The designers want to push the boundary and reach high quality and properties that can add value to this new material. Accordingly designers bring in market- and user-centred viewpoints while simultaneously challenging material scientists to raise their ambitions. The other discussion has been the positioning of the goal in two different ways: are we aiming for a goal that is easy to reach when the project ends in 2018 or are we challenging ourselves a bit more and aiming for future openings, which are not so easy to reach in the project timeline. Even so, the project goal has been quite vague and a shared understanding of what the material innovation is we are aiming for is still missing, after one year working together.

A shared goal helps to cross boundaries. In our case the future scenarios can be understood as boundary objects in the early stage, as “a map” towards a shared goal. Yet the shared goal has not been formed or argued collectively and this has caused some frustration during the process.

Moreover some boundary objects might help the multidisciplinary discussion and in our case material samples have worked as boundary objects, crossing over disciplinary borders. Touching, feeling, showing and explaining with material samples have helped to create a shared vision of future materials. Here the haptic experience, and pre-knowledge of materials and their technical and functional properties, are shared through a conversation, building a grounding for shared material knowledge and crossing disciplines.

3.3 Stepping outside disciplinary practices

Joint practices are what team members do together (Stompff and Smulders 2013). In joint practices, in workshops a shared mindset and shared vocabulary have been constructed. We have learned through joint practices what material attributes mean to textile designers, material scientists, industry people, textile engineers or to business people. On the other hand design methods have been used (creative practices) in the workshops which has caused uncertainty among some participants. Sharing and spreading knowledge among disciplines is complicated because of differences in disciplinary practices (Stompff and Smulders 2013). Designers are used to approach problem solving in an experimental and open way, using collaborative imagination as a tool for shared knowledge. Material scientists are used to working in laboratory surroundings and using more quantitative methods than qualitative ones. Yet especially in textile material development, material scientists use also material experimentations as a method to develop materials further, but always evaluating the results through quantitative methods. Industrial partners are used to fast business development and looking at things from the point of view or their customers, an intention which is not always aligned with inventing something totally new, which is quite slow development process in the material field. As a designer summarized the results of a brainstorming session: “So I’m sure you agree there’s no clear conclusion there, other than that it was a fantastic journey, push and pull between technical and creative dreaming and our industry partners saying I really want this, our customers want this.” Especially the different tempos in the design concept development path and material development path have caused contradictions. In the investigated case all partners have been challenged to step outside their comfort zone and known disciplinary practices, also designers.

3.3. Knowledge gaps between disciplines

Creative workshops have been the tool and setting, a kind of platform to build shared understanding and shared knowledge in the studied case. In the early phase of the project, workshops served participants' getting to know each other, getting to know the subject area under study and further getting familiar with the ways of working (creative practices).

Based on our empirical data we claim that a sufficient level of common understanding has not been achieved through the workshops and knowledge gaps have existed between disciplines. Special knowledge from the technical process of regenerating textile material remains unknown for people outside material science. Such specialist technical knowledge is hard to understand if you have only textile or fashion design knowledge. Here we have used a different approach to build bridges between different disciplines, which is described in more detail in the following section.

3.4. Intermediators to bridge knowledge gaps

When knowledge needs to be transferred across disciplines e.g. standardized forms work well as boundary objects, but when something new needs to be invented boundary objects are not enough (Stompff and Smulders 2015). This is especially the case when there are contradictory aims and when knowledge has to be transformed between disciplines. When there is a deep knowledge gap between disciplines, a new person is needed, a person with a different knowledge base and skillset than designers'. Based on our empirical data and results we claim that in unknown material innovation processes an intermediator (or intermediators) is needed. In our case the intermediators have been textile engineers who have been needed between material science, industry and designers. We can argue that textile engineers are accustomed to communicate with all these fields, design, industry and material science, and therefore they can represent the mediator who can visit different disciplines to create a link between them. Accordingly, they can be seen to have the same role as pointed by Star and Griesemer (1989), the boundary object which can be located between disciplines and which includes (or knows) some disciplinary practices from all disconnected disciplines. These intermediators have been most important especially for integrating all knowledge from different processes to construct the first design brief. Different kinds of information from creative scenario workshops and scientific material development work, technical limitations and industries' realities for strategic material selection according to material's functional properties, had formed a foundation for new knowledge building. In this process the goal has been the first design brief for future materials and their attributes. This needed to be formed in a language that can be understood by designers (expressing material attributes in descriptive terms), textile engineers in factories (technical and functional attributes) and moreover material scientists (expressing fibre properties in quantitative terms).

4. Conclusions

As Puonti (2004) points out, "*[i]nformation* is a central factor in collaboration: information held and acquired by various participants must be shared. However, information exchange is not sufficient to manage the transforming object: new *knowledge* has to be acquired on the basis of the information and mutual interaction. This implies *learning.* Learning is not restricted to mastering the substance of the case. The participants also have to learn to collaborate." Puonti's argument is in line with the findings from the current case, where the first project cycle can be seen as a huge learning process for multidisciplinary collaboration. After this first cycle the participants can truly move into a shared innovation process.

In the studied case a shared learning process is quite a central element of an unknown material innovation process. Shared learning challenges everyone. Everyone has to step outside their "comfort zone", their own disciplinary knowledge and professional practices. Accordingly a platform or "playground" between disciplines needs to be constructed where the shared innovation process can happen. Furthermore, everyone has to be open minded and ready to "play" with design-driven methods to start the multidisciplinary collaboration and to achieve the right mindset for shared learning. In a multidisciplinary project targeting future innovations, co-learning is key. Even if the project is defined to be design-driven, the idea is not to educate material scientists to work like designers or use methods that are familiar to designers only, Instead the point is to develop new methods suitable for this new situation where different knowledge areas are well presented. Furthermore as the design-driven approach is evolving and gaining popularity, it is good to recognise that design thinking is becoming a platform or integrative discipline, which can connect different professionals and even academic disciplines, but designers do not always have to take the lead in this.

Based on our findings we argue that in a material innovation process more than boundary objects are needed to construct shared understanding. Stompff and Smulders (2013) argue that designers can expand and cross boundaries, and therefore they have skills and boundary spanning capability. They claim that this is a natural skill for designers and they call this boundary spanning "mirroring". Mirroring means that designers are able to collect all different information needed for NPD; they can integrate all needed aspects and knowledge and show this process as a sketch, or idea or communicative prototype for a new product in a way and language that is easily understood by everyone. Mirroring can result in a solution when the product to be developed is more or less known for team members in an NPD process. Yet our empirical findings show that the process is more complex while aiming at new material innovation. Designers' skills alone might not be enough in this process. Designers will have to have deeper understanding of technical challenges to be able to design future material innovation, even in collaborative and multidisciplinary settings. Based on our findings, knowledge intermediators are needed to bridge knowledge gaps between disciplines. In our case the knowledge intermediators have been textile engineers who know different disciplinary practices and can transform knowledge so that shared understanding can happen. In our case the knowledge intermediators have had same knowledge foundation but have worked in three different contexts: material science, industry and design research. This setting has enabled the first brief to be constructed in a manner that it is possible to be understood by designers, industry and material scientists through qualitative and quantitative information.

5. Discussion

When developing future materials and unknown material properties there currently are a lot of challenges, at technical, material, design and process levels, but there are also a many opportunities to create future innovations. How to achieve design-driven material innovation? In the current case one third of the project has passed. We are still wondering if we are going towards the right goal, towards material innovation. Is the goal clear and shared? Or do designers, who are leading this process, remain too much in their own professional knowledge area and in creative practices? In the next cycle B the methods need to be developed so that other kind of knowledge is also strongly included, knowledge and methods from material science and from industrial business realities. The next cycle might be easier after cycle A, where we have learned to collaborate in a multidisciplinary setting. The next cycle can concentrate more on pushing the innovation forward. We shall study these issues further along the project. Moreover designers' emerging "NEXT" thinking skills will be under investigation, as this multidisciplinary project proceeds.

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Acknowledgements:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646226.