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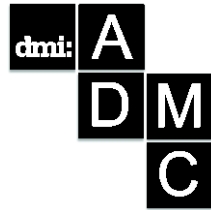
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# YABBA DABBA DOO: Boosting Multidisciplinary Innovation through a Design-driven Approach

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*The current hype that design is central to various kinds of development projects tends to gloss over how demanding collaboration and new knowledge-building is in a multidisciplinary setting. Therefore more empirical studies are needed to investigate in detail projects where a design-driven approach has been used in innovation projects, to evaluate its impact and outcomes.*

*This paper presents a case study on a project where a design-driven method is pushing multidisciplinary innovation. The study is based on participant observation. The data consists of field notes on project workshops, project participants' feedback and interviews.*

*The findings show that the design-driven approach has enabled a different process flow: it has fostered traditional multidisciplinary knowledge-building towards a more uncertain path. The experimental way of working has caused inconvenience, but it also pushed forward participants' ways of thinking and working and even created 'co-design innovation spaces'. Furthermore the process has fostered participants even towards transdisciplinary knowledge-building.*

*This case study shows how a design-driven approach and design research can combine tangible prototyping with abstract knowledge-building. Even if design is seen as a buzzword for all problem solving, this study shows that design can in fact enhance innovation potential in a complex multidisciplinary setting.*

**Keywords:** Design-driven, Innovation, Design thinking, Multidisciplinary

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## Introduction

In recent years design thinking has emerged to be the hype of numerous development projects; design seems to be a magic word that can solve all problems. General interest in design skills and capability is growing and broadening to new areas, and recently designers are invited more and more to take part in multidisciplinary projects. They are even invited to lead multidisciplinary projects, especially so when aiming to solve complex problems (Sanders, 2015) or to boost innovation (e.g. Niinimäki, Pekkala, Peltola, Person, 2015).

Yet collaboration and new knowledge-building (academic or applied) in a multidisciplinary setting is truly demanding. Therefore more empirical studies are needed to investigate in detail projects where design thinking or a design-driven approach have been used, to be able to realistically evaluate its impact, outcome and limitations especially in innovation processes.

This paper presents a case study on a project where a design-driven method is pushing multidisciplinary innovation. In the studied case designers and design researchers work together with material scientists, market experts and the manufacturing industry to develop new innovations from waste using novel technologies. In this paper we will concentrate on those topics that emerged from the empirical data to be the key issues with regard to boosting multidisciplinary innovation with a design-driven approach. Critical aspects of using a design-driven method are also discussed from the point of view of project participants. The paper starts by reviewing the literature on the design-driven approach and design research as a method, the case and data is then presented, and the results from the data are shown in dialogue with theory.

### *Design thinking and design research*

Companies tackling new kinds of complex issues or looking for new business opportunities are increasingly interested in the expanded skills of professional designers (e.g. Kimbell, 2011). Design skills form a new asset in change-making or in the quest for innovation. Design thinking can use scenario building and vision of futures to boost development towards a certain direction (Niinimäki et al., 2015). Design thinking can use inductive, deductive and even abductive thinking, meaning creative problem-solving,

suggesting that something is more than its initial impression; therefore design thinking can 'look into the future' and show 'what could be' (Cross, 2007, Niinimäki et al., 2015). As Mootee (2013, p. 32) points out:

*Design thinking is about cognitive flexibility, the ability to adapt the process to the challenge.*

Accordingly design thinking uses iterative processes and exploratory methods to construct understanding of the problem, and therefore creativity and flexibility are the core of the design thinking process (e.g. Kimbell, 2011; Brown, 2009). These design thinking abilities, flexibility in the process, exploratory approach and generative methods, are used also in the research context. In design research there are two reflective levels in knowledge creation: one links to doing, the design practice side, and the other links to thinking, the more abstract level of cognition. As Cooper, Junginger and Lockwood (2009, pp. 49-50) argue:

*Since design thinking and design methods always go hand in hand – that is, in design the thinking is informed by the doing, and vice versa - there is concern among some designers that the emphasis on thinking might overshadow the importance of making..., when design research is about the active engagement between the two.*

Design research at best can combine different knowledge areas. Tangible, tacit and theoretical knowledge can be linked together to form understanding of the situation at hand. As Kimbell (2012) argues, design thinking can be understood, not only as a problem-solving activity or abstract concept creation, but also as an action including situated and embodied material practices. In this way design research applying design thinking methods can also use materials, prototypes, experiments, activities and future visions to create new knowledge in innovation processes. What is especially interesting is using experimental design research methods to build understanding of materials which are 'to become', i.e. future materials and their 'imaginary' attributes (Niinimäki, Groth, Kääriäinen, 2018). When exploring future materials, designers can bring in their embodied knowing (Johnson, 2007): they can work with imaginary materials and their attributes based on their previous experiences with the same kind of materials or even working with substitute materials. As Norman (1993) explains, designers can

use representations to work with materials, things, events that never existed, with imaginary objects and concepts. This more intuitive type of materials research can be seen as an important approach in knowledge construction, where haptic and sensorial knowledge is combined with tacit knowledge. It adds a new dimension to the more traditional scientific process of knowledge building (Tin, 2013) and therefore builds a new layer on top of the more traditional and technology-driven materials research.

### *Design-driven innovation*

The innovation process can be seen as a management process that is not based on 'a singular event, but a series of activities that are linked in some way to the others' (Trott, 2017, p. 30). Innovation can be seen as a response to an opportunity that is context dependent. In our case the context has been a Circular Economy (CE) and within this a smaller context frame: using textile waste and novel generative fibre technology as a starting point for the innovation process. Furthermore, as Trott (2017) points out, innovation can be understood as a creative effort that ends up in successful introduction of a novelty.

As a simple linear model for fostering innovation works only in a few limited contexts, more complex innovation processes need to be created. As Trott (2017) points out, we need to examine these complex processes for innovation and especially how this complexity is managed. Cooper et al. (2009) argue that design management is moving from managing product design to more complex issues like managing the design of innovation. Accordingly design management is moving from 'lower-level product-centered design strategies to the complexities... in the organizational level' (ibid. p. 50).

According to Carloppio (2010), design skills, creative exploration, are especially important when trying to achieve novel strategy innovation by opening multiple and creative options for the future. Storvang, Jensen and Christense (2014) explain that design can be an important driver for innovation, as design can integrate bold visions, market information and technological aspects in striving for new, innovative products. This kind of process can start from technical innovation, supplier-driven innovation or market-driven innovation (user/customer-centered innovation). But design-driven innovation can combine all the previous mentioned: it can thus combine a vision with market-centered information as well as technical innovation (ibid.).

The skill to combine different knowledge flows seems to be one success factor in using design to foster innovation. Moreover a collaborative approach and co-design methods boost innovation scouting. Sanders (2015, p. 296) points out that ‘design-led innovation is not likely to support sustainable futures unless it is co-design-led innovation’. She further argues that collaboration is key for the innovation process. Therefore a successful innovative outcome is linked to the knowledge network setting and collaboration between knowledge areas. Lindegaard and Wesselius (2017, p. 85) point out that designers are able to capture the whole of ‘concepts or perspectives in the form of prototypes and sketches’ to ‘support the creative thinking of the people who engage with them - whether or not they are designers’. Therefore a new, emerging area in the design skillset is to boost collaborative and complex innovation processes.

*Design is becoming increasingly multidisciplinary, and many new concepts in design are now being crowdsourced and co-designed by people who are not trained designers. This means that the role of the design leader will no longer be to develop unique creative solutions, but one that revolves around facilitating ideas (Muratovski, p. 137).*

Building upon Muratovski, we can argue that design is not only constantly changing but also evolving towards totally new directions. This is especially so when aiming towards co-designing innovation in a multidisciplinary setting. Therefore we need to construct new knowledge about this field as well as understand this new design skillset needed for this special work.

## Case and research methods

This study aims to empirically investigate the multidisciplinary collaboration in a research and development project [Trash2Cash](#). The project consists of 18 stakeholders from ten countries and runs for three-and-a-half years. The overall objective in the project is to develop new materials and products from waste materials *via* creative design in the context of a Circular Economy.

The general goals of the project are to:

- Integrate design, business and technology into a coherent discipline to establish new creative industries;
- Develop new material and product opportunities via creative design from waste or process byproducts;
- Reduce the utilization of virgin materials; improve material efficiency, decrease landfill volumes and decrease the energy consumption;
- Use design for recycling with the vision of closing the material loop;
- Create new business opportunities by adding the return loop of the discarded goods to be recycled into attractive products; and
- Promote development of the creative sector by providing technological solutions for exploitation of waste streams.

The whole project is defined to be design-driven. Therefore creative collaborative methods are used to boost innovation in a multidisciplinary setting. The methodology team consist of design researchers from academia, designers from consultancies and industry and the project manager (a technology specialist). The methodology team is responsible to orchestrate and lead the design-driven process. The process consists of three iterative cycles which enable knowledge transfer between the different disciplines: the design stream (designers and design researchers); the science and technology stream (material technology researchers and developers); and the manufacturing stream (manufacturers and consumption researchers). The whole project is constructed around 9 work packages, but the main design-driven activities happen in workshops which are organized four times a year. Here all stakeholders, around 35 participants in each workshop, work together for 2 days with creative and explorative methods and using design tools to solve problems and push the project further (see more details here <https://www.trash2cashproject.eu/>).

In this project designers have had many roles: they have been facilitators creating creative workshop settings, trendsetters and scenario builders, concept designers and product designers; they have defined material attributes, they have done material tests and design prototypes, they have combined all information flows from different work packages, they have visualized knowledge and they have collected data to analyze the collaboration process. Designers have combined traditional design skills (e.g. textile designer, clothing designer, product designer) with emerging design research skills (facilitator, designer of interventions, co-designer, academic design reseacher) to create collaborative activities and even a collaborative

mindset in the project and moreover to construct new multidisciplinary knowledge.

A case study methodology was adopted in this study. Case study research is particularly suitable for studying emerging phenomena whose dimensions are not yet fully understood (Yin, 2003). The method of participant observation has been used for collecting data. Data for this study consists of field notes of project workshops over 2.5 years, project participants' solicited feedback after each workshop session and participants' interviews. The aim of this study is to identify what the design-driven approach has meant in this special case and how design methods have been used in the aim for multidisciplinary innovation, at a stage when two-thirds of the project have been completed. The special interest in the study described in this paper was to get feedback from material scientists and their experiences of the design-driven process (5 material researchers were interviewed in January 2018). Especially the advances, impacts and limitations of using design-driven methods in multidisciplinary collaboration have been analyzed. The findings have been reflected against existing design theories to enhance the knowledge of design-driven approaches in a multidisciplinary setting.

## **Results**

This paper will focus on the Fuzzy Front End and bridging-the-gap stages in the innovation process. Kim and Wilemon (2002) define the Fuzzy Front End phase as the period starting from discovering the opportunity and developing it further until it is ready to be implemented. The Gap is the period when it is time to identify that there are enough good ideas and ideation needs to stop, proposals are evaluated, some are excluded and best proposals are selected and developed further to be implemented in the next product development stage. As the third phase, the product development phase, is still ongoing in the studied case and seems to be more straightforward, it is excluded from this study. Table 1 summarizes the findings of this study and in the next section the main findings are described. Quotations from material scientists' interviews are used to support the arguments.



Table 1 Design-driven process for innovation.

Phase	Design actions	Impacts	Advances	Limitations
<b>FUZZY FRONT END</b>  <b>Co-playing and co-dreaming</b>	<ul style="list-style-type: none"> <li>-Imagining</li> <li>-Inspiring</li> <li>-Facilitating</li> <li>-Visualizing</li> <li>-Collaborating</li> <li>-Playing with substituting materials</li> <li>-Evaluating first round material prototypes</li> <li>-Prototyping</li> </ul>	<ul style="list-style-type: none"> <li>-Experimental and creative knowledge building</li> <li>-Building the community</li> <li>-Pushing boundaries</li> <li>-Constructing co-design innovation space</li> </ul>	<ul style="list-style-type: none"> <li>-Opening future opportunities</li> <li>-Creating knowledge network (tacit, haptic, industry, intellectual, academic)</li> <li>-Learning to collaborate</li> </ul>	<ul style="list-style-type: none"> <li>-Frustration</li> <li>-Confusion</li> <li>-Misunderstanding</li> <li>-Conflicts</li> <li>-Lack of disciplinary knowledge</li> <li>-Lack of shared goal</li> </ul>
<b>BRIDGING THE GAP</b>  <b>Co-visioning</b>	<ul style="list-style-type: none"> <li>-Concept designing</li> <li>-Storytelling</li> <li>-Integrating knowledge flows</li> <li>-Evaluating concepts</li> <li>-Second-round prototyping</li> </ul>	<ul style="list-style-type: none"> <li>-Engaged partners</li> <li>-Shared vision</li> <li>-Shared goal</li> <li>-Excluding options</li> </ul>	<ul style="list-style-type: none"> <li>-Shared understanding</li> <li>-Framing and reframing to find the right focus</li> <li>-Constructing clear directions for the development work</li> </ul>	<ul style="list-style-type: none"> <li>-Wrong focus?</li> <li>-Complex and slow decision-making</li> </ul>
<b>PRODUCT DEVELOPMENT</b>  <b>Co-producing</b>	<ul style="list-style-type: none"> <li>-Constructing prototypes based on design concepts</li> <li>-Disseminating</li> </ul>	<ul style="list-style-type: none"> <li>-Innovation opportunities identified</li> <li>-Clear process</li> <li>-Deep collaboration</li> </ul>	<ul style="list-style-type: none"> <li>-Communicating to external audiences through prototypes and stories</li> <li>-Looking for market opportunities</li> </ul>	<ul style="list-style-type: none"> <li>-Risk for limited view on innovation</li> </ul>

### *Constructing a 'Co-Design Innovation Space' in the Fuzzy Front End Uncertainty phase*

*It has been like simultaneously visiting all the time in the kitchen and cooking the soup while at the same time eating dinner (comment from a material scientist on the design-driven process).*

The starting phase, the Fuzzy Front End of product development, is a stage where all the various opportunities are exposed, where participants are inspired, all kinds of information is gathered and shared and there are many activities to explore the open-ended questions (Sanders, 2015). In most cases there is no clear existing knowledge on how to proceed through this phase and which path to follow. The idea is to keep this process open and extend it for as long as possible to find all options before narrowing the process down by making decisions for the next development stage. As Sanders (2015) points out, this phase is important not only to find the best ideas but also to identify and evaluate which paths not to follow (to exclude).

Designers are used to working in this way, and keeping the process open for as long as possible is also a way to find and develop as many ideas as possible. Through this way of working designers aim to firstly frame the problem area correctly and secondly to enhance the best ideas for the situation at hand. Designers are used to uncertainty in this phase and they aim to prevent 'anchoring the solution or answer to a research problem, as this often aids in developing concepts and knowledge building further, reaching more developed and sophisticated results' (Niinimäki et al. 2018). At best the Fuzzy Front End phase provides an opportunity to construct 'a co-design innovation space' where exploration and creativity can be enacted in a collaborative manner. As Sanders (2015) point out, shared activities and a 'shared participatory mindset' can help cross disciplinary boundaries. Disciplinary collaboration can enhance the innovation potential when all expertise and skills from different disciplines are integrated together. Yet the process can be fuzzy.

Various types of design research methods have been used in this phase. Traditionally this has also been the phase where the end-user information (from product users) has been brought into the design process. In our case the end-user-centered information has not had a large role, but the

feedback from industry (who represents the user sector in this case) has been crucial.

Because in our case the material innovation process is more complex and uncertain, new methods needed to be developed. Explorative, experimental and even experiential methods have been used to combine tacit, haptic and even sensorial knowledge with technical knowledge in the context of material development. Here haptic knowledge and previous material experiences have especially been used, as future material attributes have been explored through playing, touching, and experiencing with substituting materials. Through these shared creative actions the knowledge community has been slowly built. This process has not been easy.

*Entering the stage is the best moment in the play.*

*When life was still good.*

These quotes above from the material scientists' interviews show the high positive expectations at the beginning of the process. Soon after problems began and material scientists felt that their process and efforts were not understood by the other participants (more on this in the next section).

*Communication was hard, we tried to make everyone understand what we are doing (material scientist).*

Furthermore the Fuzzy Front End phase caused much frustration among some participants, especially those who did not have any earlier experience with this working method or did not have any touchpoint of working with designers in this manner.

*It took a really long time to understand what the project is about (the design-driven approach) and why we are doing these activities in the workshops.*

The disciplinary differences and existing knowledge gaps extended the Fuzzy Front End stage and this delay has caused frustration among participants. Especially the material researchers felt that this phase took too much time and caused problems in their own material development process. Especially challenging in this way of working has been the collaborative decision-making. The slow process of decision-making has caused delays in the process flow. Moreover different kinds of development

tempos and different expectations and disciplinary practices (e.g. technical readiness level, business expectations, the slow process in knowledge-building in research) have caused confusion with regard to time, scale and outcome expectations. Obstacles in the process have included not only knowledge gaps and disciplinary differences, but also different kinds of individual or disciplinary interests.

While for some the design-driven way of working has been a challenge, some comments show that this kind of multidisciplinary collaboration can be learned. Material scientists commented that it was easier to collaborate with design partners with whom they have worked before in an experimental setting. Positive experiences can build trust and deepen the communications between disciplines.

### *Collective creativity*

Sanders (2015, p. 296) argues that collaboration is key to the innovation process; creativity and communication are shared and we can thereby make sense of complex issues collectively. Accordingly creativity is not owned by the designers in multidisciplinary collaboration. 'Collective creativity refers to acts of creativity that are experienced jointly by two or more (and sometimes even crowds of) people' (ibid., p. 296).

When the material scientists were asked 'who have been creative in this process' they pointed out that creativity has blurred and dissolved in the project.

*I would say everybody (has been creative), of course, on different levels, but I think everyone has proved (to show) some sort of creativity.*

*At some point, these lines got dissolved and got blurred. That you can't really distinguish anymore between the typical research and the creative design. Or we could approach each other, let's say so.*

When aiming for future innovation designers have pushed boundaries and challenged especially material scientists to create materials that include attributes with some competitive edge. Designers have not been satisfied with material attributes that are easy to achieve with this available technology and at the same time promoting the market potentialities of

new, unknown materials. This approach has fostered material scientists to challenge their own knowledge and skills.

*It has been so challenging a process that I have needed to use a lot of my own (technical) creativity to be able to achieve what they (designers) want (from material science).*

*I have needed to stretch borders in my own thinking (material scientist).*

Material scientists felt that working with designers in a creative setting pushed their own thinking and they have had to push their own technical innovativeness.

*You know your own box, inside which you can work. Then somebody comes and says that you have to knock down one wall in that box. Then you have to mix in a new ingredient into the “cocktail” so that you can get out of that box.*

The previous comment from a material scientist shows the way designers can challenge the engineering linear way of thinking and to push the limits, even without knowing the technical process in detail. A design-driven approach can foster a mindset of collective creativity, which enables the team to cross over the Fuzzy Front End phase into the next phase. The design-driven process can trigger interest in the future. Designers’ visual presentations and imaginary skills can invite participants’ thoughts projected towards the future, and this can be a core skill in building a shared vision for the project.

### *Gap*

As designers have entered various kinds of collaboration settings where several disciplines are present, discussion on gaps between researchers and designers are becoming salient (e.g. Sanders, 2015, Niinimäki, Tantt, Kohtala, 2017). Sanders (2015, p. 297) points out that gaps can be ‘the source of conflict, misunderstandings and lack of respect’. These characteristics have all been experienced also in the studied case. Niinimäki et al. (2017) concluded that knowledge gaps can cause conflicts and prevent the project from proceeding, especially when the development work is

grounded upon a technical innovation that is not yet mature and that needs deep technical understanding. Such a situation may be challenging for designers or business partners to understand. On the other hand other disciplines entering the 'design landscape' (Sanders, 2015) find it difficult to digest the exploratory way of working and especially the uncertainty of the process.

Especially the Fuzzy Front End phase includes extra challenges if the disciplinary differences are wide or if some of the participants have not done this kind of creative collaboration before. Therefore the existing gap can be wider than in a normal NPD process.

*I remember that these workshop agendas, when I got them, I think I haven't understood a single one. And maybe that's because it was always made by a designer. And they're clearly, I don't speak that language.*

*The workshops were really tough, I think, in many senses.*

Based on the interviews we noticed that in the studied case all knowledge has not been openly shared. Especially the early phase of the material development has been familiar only for participants in that work package. All technical challenges in that process phase have not been made known to other partners and therefore the material scientists' efforts in the early phase have been unknown to others. To some level this has caused unrealistic expectations among designers when they have been creating visions for these new recycled materials. On the other hand a material scientist commented that it might be good if designers could come to the lab early enough to understand the technical process in detail and to be able to include some design aspects already in the early material development phase. Obviously the knowledge transfer has not been successful at the beginning, which has caused conflicts and created a gap in the process flow. Exposing work to other disciplines early enough and opening up disciplinary practices and knowledge to other disciplines seems to be a critical point in a large and complex process towards innovation as T2C has been. This needs an open mind and readiness to learn from other disciplines from all participants.

Moreover some actions in the project's early phase at the beginning of the material development have locked the development to a certain

outcome. While there always are some limitations, it may be that a more open process at the beginning and keeping even more material options on board longer, might have offered other innovation options at the end of the process.

In the gap phase the shared learning that has occurred throughout the Fuzzy Front End phase, should build a shared mindset, shared vision and a common goal, which ties the next product development stage to a certain path. As Kim and Wilemon (2002) highlight, it is important to identify how the learnings from the Fuzzy Front End are captured and used in the next stage, in the product development stage.

*I think the entire project will be a success, once we are able to look back at it. Because obviously from the frustrating points we have learnt a lot about how to deal with others, learnt a lot how we should behave when talking with others. I can see that already happening, that it was a long learning process.*

### *Engaging partners to bridge the gap through storytelling*

A strong asset in using a design-driven approach in innovation is storytelling verbally and using future scenarios to visualize the idea that is collaboratively constructed. Storytelling may be difficult for some partners who are not used to using verbal skills to link to their own tacit knowledge (Sanders, 2015). Here designers can help. By sharing dreams of future materials and scenarios of future application areas, designers can also transmit their ideas to other (e.g. more technical or business-oriented) disciplines. Storytelling can also keep the dream alive throughout the long project. This is one way to keep people engaged in the process through each step. Moreover storytelling is a way to bridge the gap between the Fuzzy Front End stage and the more straightforward product development phase. In our case the storytelling has condensed into concept designs, 'Master cases', which are selected to be the ones ready for product development and the prototyping stage.

## **Discussion**

### *Meaning making with the help of design skills*

Antle and Fraser (2017) argue that at best, design thinking can be understood as a process where a designer's material practices can

contribute to the innovation process by relating these design competences to meaning making. A process of combining tacit and intuitive knowledge with more academic knowledge can be seen as cognitive processes of meaning making. In this way knowledge creation and understanding can be linked to experiences and even to intuitive ways of knowing. Designers are able to enhance a collaborative innovation process by capturing different knowledge flows and different perspectives, and based on this process design they can visualize a concept or construct a prototype. This concept or prototype can be shown to others, which further enhances collaborative knowledge creation and the whole innovation process can be iterative (more so than linear).

Designers' reflective skills (Schön, 1983) are used even with people with no design skills. Therefore a design-driven method supports creative thinking and co-thinking throughout the process and it involves creativity from all partners, whether they are designers or not. 'Sketches and prototypes assist the dialectic process of creative discovery in collaborative situations,' argue Linaard and Wesselius (2017, p. 89). Creating scenarios, visualizing possible futures and visually 'explaining' or 'looking for' different options seem to be central to finding novel perspectives, and therefore this reflective practice is an important part of design-driven meaning making. As Lindgraad and Wesselius (2017, p. 90) highlight, based on the aforementioned characteristics, 'the details of a solution are as much discovered as created.'

### *Process flow towards knowledge building*

The findings show that the design-driven approach has enabled a different process flow; in turn, opening and narrowing the development process in a design-driven approach has shifted traditional multidisciplinary knowledge-building towards a more uncertain, shared and collaborative path. Furthermore disciplinary borders have been lowered through shared actions.

*Unbelievable that this process has succeeded to make everyone with different background to collaborate and do things together.*



On the other hand the experimental way of working has caused inconvenience but also pushed and challenged participants' way of thinking and working.

*It's not an easy way but it's possible to work that way.*

Furthermore the process has fostered participants even towards transdisciplinary knowledge-building, crossing over disciplinary boundaries to learn each other's disciplines and others' 'trades' (Grix, 2010). In some moments even cross-fertilization has been observable, where 'scholars learn from each other, share methods of research and are willing to accept different interpretations of events' (ibid., p. 99).

*I admire a lot the deep expertise of designers. I have learnt a lot. Especially the way designers think and create new ideas. Through observing designers' way of thinking I have learnt a totally new mindset, a new strategy and this has had a deep influence on my own thinking.*

*I guess we really learned a lot from other areas. Because before that, I was so much focused just on what I was doing.... I just felt that my stuff was important, but not other people's stuff, like really. And it really showed that there are so many people involved, and everyone's got their role.... I learned a lot about these things. I did not even know what design-driven was before I started.*

## **Conclusions**

### *To win the race for innovation*

Through inspiring, questioning, shaking, breaking and pushing over boundaries greater potential for innovation has been explicitly fostered through shared learning. Furthermore the design-driven approach has enabled framing the goal of the innovation in a temporal and challenge scale.

This case study showed how a design-driven approach and design research methods can combine tangible prototyping with abstract knowledge-building, haptic and creative experiences with cognitive knowledge-building, emotional experiences with technical knowledge, and further bringing in commercial reality to strive for future innovations. Even if design is seen as a buzzword for all problem solving, this study shows that

design can in fact enhance innovation potential in a complex multidisciplinary setting, but this needs reflective and flexible process orchestration.

On the other hand there are limitations to approaching innovation with design-driven methods. The Fuzzy Front End phase, especially when extended, causes much frustration and conflicts. All disciplines and business partners are not ready to expose themselves to long-term uncertainty and an explorative way of collaborating. This may cause more or less serious conflicts, but as our case shows it can be possible to overcome these obstacles to achieve deep collaboration. Especially the Fuzzy Front End phase includes extra challenges if the disciplinary differences are wide, there are deep knowledge gaps or if participants have not participated in this kind of creative collaboration before.

On the other hand there is great potential to win the game, the race towards innovation. As the following quote from a material scientist's interview highlights:

*If it is an easy road and easy to implement through technology, there is no big win to achieve. Here exists that kind of driver that can change the development and something valuable can come out.*

With this comment the material scientist wanted to highlight how it is possible to achieve higher gains with a design-driven process. Kim and Wilemon (2002) argue that knowledge networks are the best way to work in the Fuzzy Front End stage to improve the ideation process and to avoid missing any promising ideas; combining different knowledge areas can thereby foster real innovation. The core competence of a new product can be found in the Fuzzy Front End stage and therefore the process, even if it is fuzzy, needs management (ibid.). Reid and de Brentani (2004) highlight that in a discontinuous innovation process there is a much uncertainty, but activities done in the Fuzzy Front End stage can at best lead to competitive advantages when the product is launched. On the other hand decisions made in the Fuzzy Front End phase might limit the innovation potential at the end of the process. This case study showed that at best, a design-driven innovation process can provide a collaborative platform and a way to enhance multidisciplinary knowledge sharing and finding the best ideas for further product development.

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