Journal of Professional Communication jpc

The superhero and the DJ: Science meets design

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Article Info

Article Type:
Research Article

Article History:
Received: *2013-12-02*
Revised: *2014-04-26*
Accepted: *2014-04-29*

Keywords:
Interdisciplinary communication
Material design
Material identity
Hierarchic design
Kofes

Abstract

This article describe several examples of art and design influencing industrial processes. In this hybrid work scientists and designers have been working together creating new materials development tools, through a process of Research, Development and Design (R&D&D) and Hierarchic Design. The process, which shortens time to market and allows tailored materials to be developed, is described and exemplified.

Material scientists are super heroes, or can at least produce and emulate super-forces like invisibility (Stealth technology), super-elasticity (TiNitol shape memory alloys), fire resistant garments for Formula 1 pilots, and supersonic transportation air fighters and the Concorde. Academic scientists are trained to break world records or to produce unique materials in order to publish, but the market is seldom interested in academic records. Results that could change the world are hidden in seldom read scientific journals. Fantastic materials are hidden in forgotten laboratory drawers.

Disc jockeys (DJs), create the ambience and make things happen. The DJ controls the crowd, knows what to play and knows what the audience wants. The DJ can mix, remix and introduce new music. Designers, like DJ's, know the market, know the context and are interested in new materials allowing new designs or new experiences.

Traditionally, materials development has been driven by two different

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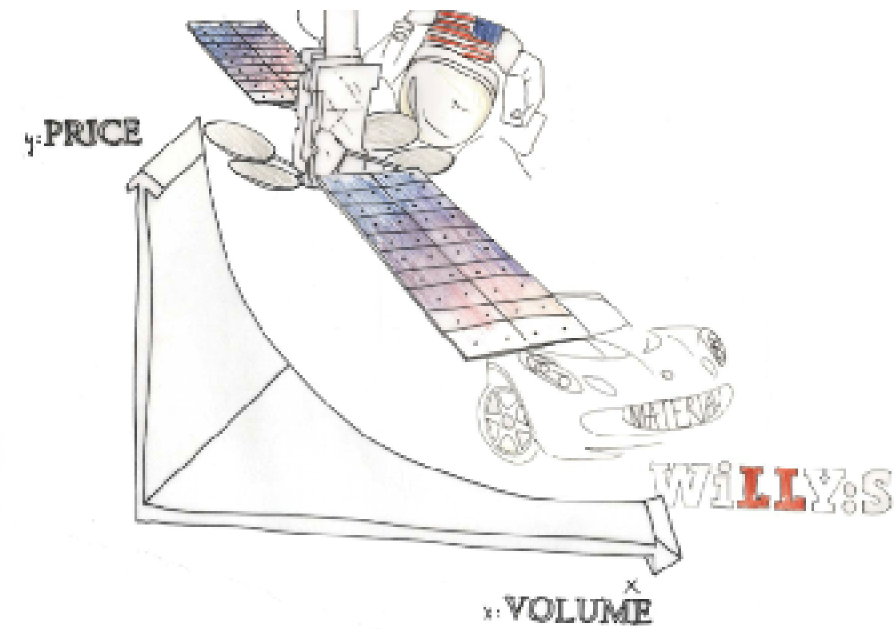
driving forces (see Figure 1). The development within aerospace, medicine and military have demanded new materials in order to overcome technological problems (e.g. to find super light materials, materials compatible with the human body or materials that will be transparent to radiation of certain wavelengths). Money has not been a limitation; there has been a need for small volumes of very special materials that can solve a given problem. Over time, some of these materials have turned into commodities and become available in larger volumes at reasonable prices (i.e. Teflon® and super alloys). The other major driving force has been to find cheaper high volume solutions for the manufacturing industry. In order to keep the profit margins on a tougher market, new cheaper materials solutions have been needed. These materials can be seen as substitutes; they are developed to substitute materials that already exist and they usually have to fit in the existing production processes in order to be competitive price-wise. They have to be cheaper and better performing in order to take market shares.

Figure 1: The relation between price and volume for commercial materials. New materials are expensive but once the volume gets big and patents expire, the price will fall. The figure also demonstrates the two driving forces in materials development; the development of technology driven high tech materials and the search for cheaper commodity materials (Lindström et al. 2008).



Recently, the fear of an oil shortage and the global warming discussion have introduced a third driving force in the development of new materials: the biobased, low-carbon footprint materials that can save humanity from peak oil and the global warming crisis.

The EU has promoted alternative agricultural production as food production has become too expensive in Europe. At the end of the twentieth century the cultivation and production of flax, jute, hemp, *Mescanthus* and other one-year crops for fibre production were subsidised. Industry was looking for bio-fibre replacement of glass fibres in composites, the biofibres having lower density than the glass fibres and higher specific properties (e.g. higher strength per weight unit). A major problem was the absorption of humidity creating a rapid degradation or big change in mechanical properties in humid environments (Hua, Zadorecki & Flodin, 1987).

In the US, the development of Wood Plastic Composites (WPC) had a very promising start during the same period. Sawdust was mixed with recycled polypropylene and extruded as a wood replacement in fences and for decking. In the beginning, these WPC materials turned out to create a lot of problems as they also suffered from water and humidity absorption. However, many of these problems have since been solved (Klysov, 2007).

Today there is a market for both these material types but a major problem for the acceptance has been that these new biobased or partly biobased materials have been developed as replacement materials, compatible with existing production processes. They have to be cheaper and better in order to take market share.

A major question connected to the biobased driving force is: How do we introduce new materials on the market?

This work describes the collaboration between scientists and designers during the process of developing new materials and their introduction on the market.

R&D&D – Research, Design and Development

In a project called New Fibres for New Materials (NFNM), financed by industry together with VINNOVA, the Swedish Governmental Agency for Innovation Systems, we explored the possibilities to use wood-based pulp fibres as reinforcement in plastics. We studied how changes in the individual fibres were reflected in the final material properties. Micromechanics and modelling allowed us to back-calculate material properties back down to fibre properties. The general idea was to find the limits for how and when wood based fibres could be used in composites and in which applications. The vision was a concept allowing tailor-made solutions where different material components could be mixed and processed in a way that the material structure was controlled. The material structure itself controls the material properties in the final product.

During the project NFNM we were contacted by architects and designers that had heard that we were developing new biobased materials. They wanted to know everything about these new ideas. We invited some design students for a first meeting and showed them all our mathematical models, tables and the curves demonstrating Young's modulus, impact strength, strength and stiffness. The designers asked for material samples and we showed them the slabs or what was left of the "dog bones" used in material testing (see Figure 2). We never produced more material than what was needed for testing and evaluation.

The designers did not look at our tables or curves; they were enthusiastic over the sensory properties in our test specimens: the visual aspect, the touch and the sound when knocked on. We were focused on the mechanical properties and they asked for the aesthetic values of the materials.

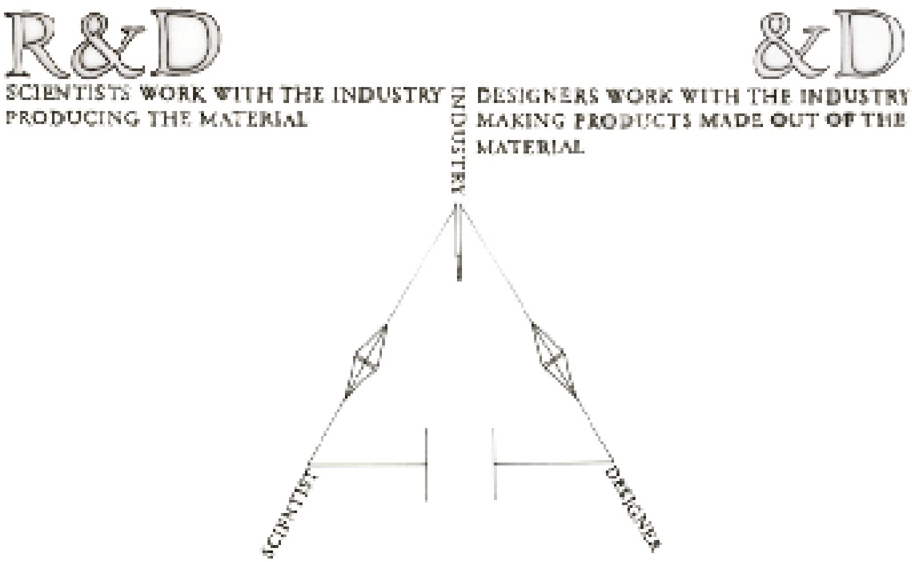
Figure 2: "Dog bone", a material test specimen used in the analysis of a material's mechanical properties. The sample is bent, stretched and twisted until break while the mechanical forces used are measured.

We had so far only been listening to engineers that gave us specifications for materials to be used in car interiors and other technical applications. No one had ever considered the perceived aspects of the material or if discussed it had to be similar to the materials used today. Also, many specifications had been set starting from existing materials and not from the actual need. The designer/engineer wanted aluminium or steel and all the mechanical properties from the desired material was incorporated in the specification.

At this point we realized that we needed to know what the market really wanted. We started working together with designers and perception psychologists.

When analysing the situation together with scientists and designers, we found the following to be the normal state of business:

Figure 3: The left side illustrates the communication between academic scientists and Industry, The right side shows the communication between the designer/the market and the market/ sales department at the same company. There is very little communication between market and the R&D department and there is no communication between designers and academic scientists.

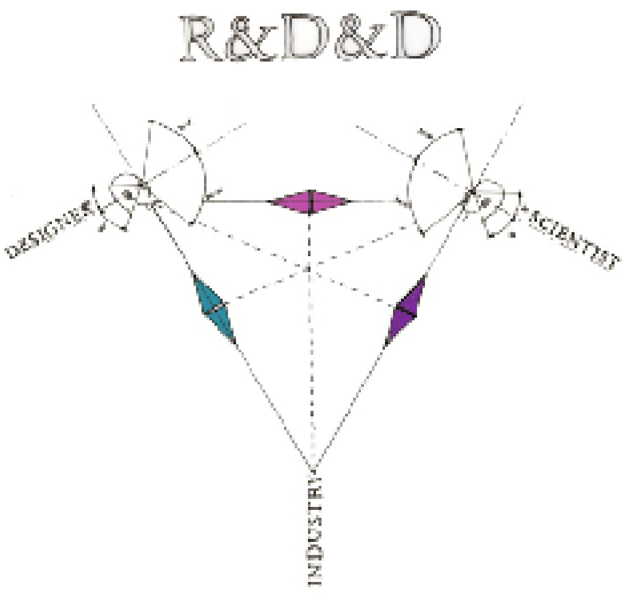


Scientists in academia and at research institutes very seldom have direct contact with designers and the market. Research is guided towards the big questions and the global challenges. The funding rules are such that publication in high impact journals is favoured and no one can publish anything that is not better than what has been published earlier, or it has to include groundbreaking new results or methods. When scientists have contact with industry it is often through the different companies' R&D departments. R&D engineers and scientists have the same academic background as the university and institute scientists – they speak the same language and oftentimes have known each other since university. The industrial scientists are ideally developing new products and processes. At the same companies, the sales department often has their bonus-based salaries – they need to sell more in order to have a better salary – and as long as their products are competitive on the market, they are happy. They consider the R&D people to be the fire brigade that will help if anything goes wrong and adjust the product to customer needs. The sales people have contact with the market but they often meet a customer that already knows what they need and asks for a quotation.

Designers working on a new product will contact different materials libraries or companies to find out what materials are available on the market. They have no contact with the R&D engineers and even less with the academic scientists. Designers often work under a time constraint. They need to use materials and processes ready available.

As a result of these findings we decided to create the R&D&D concept – meaning that industry, academia and designers work together from a common platform. Acceptance and understanding of the respective competences are fundamental. The designer will ask for certain material properties linked to function in the product, industrial engineers will give process restraints and the scientists will have new challenges (Figure 4). Material design and development cannot be performed as a stand alone project in a science laboratory, input is needed from manufacture, design and market needs and this is what the R&D&D concept facilitates.

Figure 4: The Research, Development and Design platform. Designers, industry and scientists working together in the development of new material concepts.



Hierarchic Design

Within the R&D&D concept, we wanted to develop a composite material concept that would allow tailor-made materials for specific applications. The structure in the material will define the material properties and a composite material consists of different components: fibres, polymers, plasticisers, binders, fillers, pigments, and different modifiers like anti-oxidants and fire retardants. We called the idea Hierarchic Design and defined four different levels of design:

Ground level: On this level we study material structures and develop analytical methods as well as micromechanical models.

Component design: On this level we study and develop different components, polymers, compatilisers and reinforcement fibres. Contrary to well-defined man-made fibres like carbon fibre or glass fibre, where the mechanical properties can be found in a handbook, biobased cellulose fibres have a wide spectrum of properties. These mechanical properties can vary greatly, depending on where the plant has been growing, when it has been harvested and how it has been processed. The fibre wall as well as the fibre surface can be modified.

Material design: On this level, we decide which components to blend and in what proportions. Should the fibres be randomly oriented or parallel? Should the fibres be un-bleached or bleached? From which plant species should they be derived? Surface modified or with a cross-linked fibre wall? What polymer should be chosen and which production process? Hot pressing, moulding or injection moulding will give very different structures.

Product design: The product design will define the material properties needed in an optimised design. The designer and the production engineers will give the product and process restrictions and hence define the material structure. The material structure can then be calculated from the models developed at the other levels, allowing the correct combination of components and production processes to be chosen.

The designers are present from the start in the hierarchic design projects. Together, scientists and designers set the specifications and work collaboratively throughout the whole process, meeting in the laboratories to discuss experiments and results. The physical presence helps to bridge the differences in language – tables and formulas are not needed when you have a piece of material in your hand.

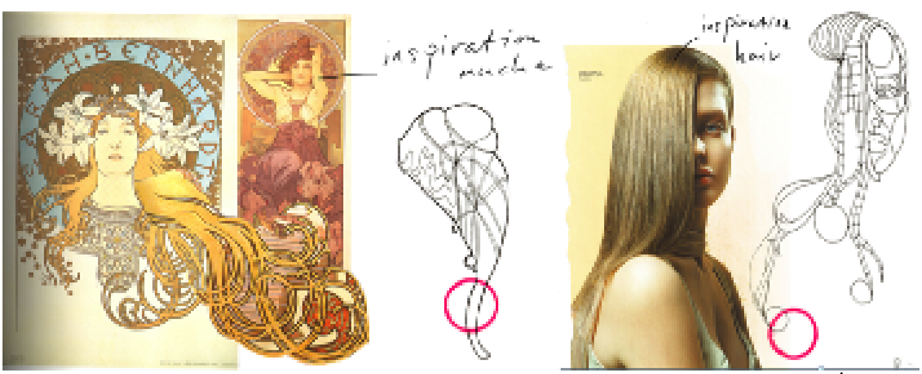
The two first levels are dominated by scientists and influenced by design, while designers and scientists are equal in the third stage. The designer leads stage four (product design) but continues to have the scientists in mind.

The Kofes

Material samples are often just slabs from the lab; they have been tested for stiffness, elasticity and other technical properties (see Figure 2 above). Other samples are simply produced using borrowed tools in order to show how the material looks in a 3D shaped part. A problem with these borrowed tools is that the beholder gets blocked on where and how the material can be used; the sample specimen being a cup or a piece of furniture etc. indicating what application the new material should be used in. Due to this we decided together with our designers, to produce a material sample that should be neutral to the application and still demonstrate the identity of the new material.

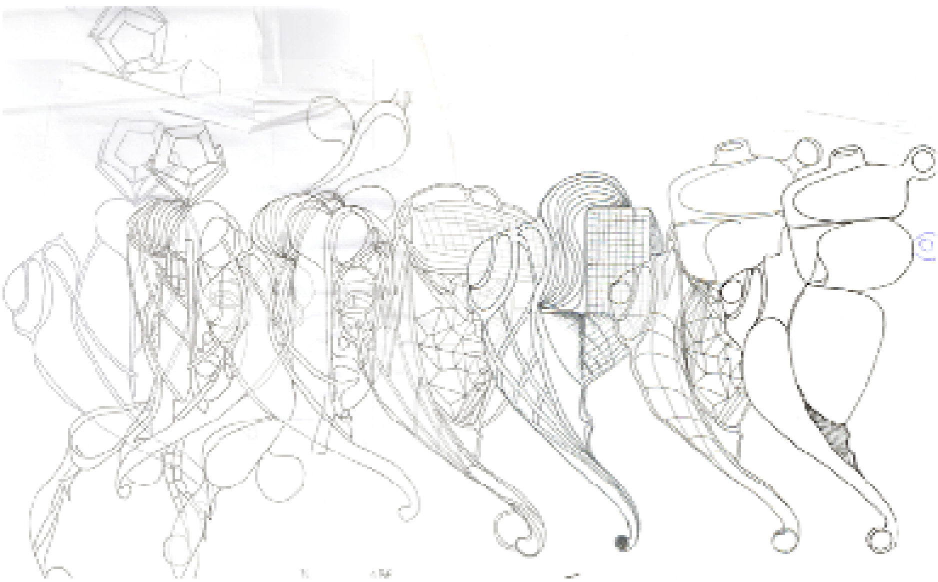
In order to find the market needs for new bio-based materials and to show these new materials without giving an indication of the use, we engaged our designers, The DJs that make things happen. We gave them one of our materials under development and asked them to identify the materials identity and its possibilities taking process limitations in consideration and to create a "KOFES". The material sample was named "The Kofes" after a Swedish short story (4) written by Birger Vikström (1958). A Kofes is something that has no use and does not look like anything else. It should not give any associations on what it is or how to be used.

Figure 5: The inspiration. Both designers choose a theme that they started to develop individually.



Designing something that is nothing and does not resemble anything else is hard, not to say almost impossible. The two designers started out individually, inspired by two different sources (Figure 5). During the work they swapped drawings, added and removed what they did not like and eventually merged their works, (Figure 6).

Figure 6: The Kofes is materializing.



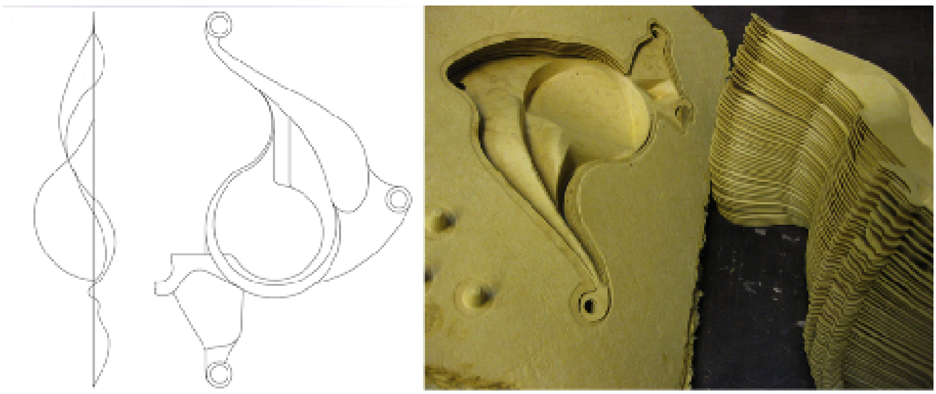
The Kofes shows what can be done with the material in a certain production process, in this case a vacuum moulding process originally developed for production of egg-boxes.

A tool was produced by Br Hartmann A/S and a set of Kofeses was moulded (Figure 7). The Kofes was first displayed during the 2007 Design Week in Milan, in conjunction with the big furniture fair, Mobile. Designers and architects from all over the globe wanted to know more about the material. Where can it be bought? The cost? Is it approved for the use together with food? Delivery time? We had to confess that we had the only ten kilograms existing in the world in our laboratory. Designers that really wanted to create a product contacted us and we introduced them to the pulp producing company SÖDRACELL who, inspired by the demand, promised to produce a batch.

A children's chair, Parupu®, was displayed at the fair two years later and the following year a desktop lamp, w101®. The material developed together with designers, Durapulp®, has just recently been introduced on the market ("A Durable Paper," 2013). Durapulp® is a fully biobased composite material with properties comparable to most other standard plastic composite materials except for the perceived quality, it is perceived as a paper material but with the mechanical properties of a traditional plastic composite.

The DJ sped up the process and made the market move, creating an added value in the difference between bio-based materials and petroleum based materials.

Figure 7: The final drawing of the Kofes and the first moulded examples, which were displayed during the design week in Milano 2007. Design Farvash Razavi and Nandi Nobell.



This has led to a new interdisciplinary work process: The Research, Design and Development concept, R&D&D, which has become an interdisciplinary process in the materials development. We are now presenting our new findings at design fairs and in art exhibitions and get a much higher impact. We reach brand owners and converters already in the development phase of the new materials.

A recent example is our mechano-active material under development and demonstrated in a self-expanding bowl designed in collaboration with the design duo *Tomorrow Machine*. The design and the material were rewarded the 2013 Dieline Sustainability Award and the 2013 Plastovation Innovation Award for Biobased Materials.

The collaboration between material scientists and perception psychologists at Innventia and designers continues. A recent project, MOULDPULP, has been focused on an injection mouldable quality of Durapulp®. We have been contacted by several different designers asking for a material that differs in perceived qualities from petroleum-based plastics (Lindberg 2013).

The collaboration between scientists and designers continues and the list with future materials, their properties and processes is growing and becoming a foundation for a future sustainable society.

Conclusions

Despite the obvious practical reasons for using production methods of the past or following examples of how things used to be, the future ahead of us will need solid improvements in every perceivable way. We all need to remind ourselves that the present is the breeding ground for the future – the seeds we plant today will grow to become the crops of the time to come. Every investment we make now will – or won't – develop into the industries we have not yet imagined. All professions need to educate each other by every means possible. Imagine the least likely scenario of the future: mankind connects with an alien species. How would we get anything of our continuous evolutionary relevance through at all? There are layers and blockages between all professions, even within the same cultures and nation states around the globe, and teaming up for a better future is more symbolic than genuine in most cases. The ever-present question is: Who pays for it all? In reality – as cliché as it may sound these days – we borrow the future from our kids; the very same kids for whom the next generation of city plans, fashion, business, politics, and pharmaceuticals are being developed. Who thinks of these people as a group rather than dear, single individuals?

We want to collaborate; to design the full experience of the future generations rather than leave them with what's left after generations of failure to think ahead of the whole game rather than one's own game. It needs to be science to be perfect but it also needs to be designed to be perfect. Neither of the two needs to be more relevant than the other – if it is not aiming for perfection, it is not aiming towards a future to believe in. Ambitions that stretch further than instant revenue is a currency on its own but need to be priced and cherished fairly. All need to act locally for a future business climate that works for everyone, everywhere, and no one should be led to believe there is a certain future waiting for us already – the trends can be broken in favour of greater visions and more relevant goals. This is not an idealistic view of the future or present, it is the simple truth underlining causality. Envision a working model for a sustainable planet, make the calculations – allowing for cultural differences – and see clearly who we need to be today. Invest in the flexible future that will cater to needs you don't even dream of. Make it simple, fun and rewarding – that's what R&D&D is about. The future needs to be our favourite place without the present being an obstacle.

Acknowledgement

This work has been developed within the industrial research cluster, New Fibres for New Materials financed by Industry and the Swedish government VINNOVA.

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