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INNOVATION AND DESIGN INSPIRED PRODUCT REALIZATION

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ABSTRACT
Long term growth and future jobs in society rely on that industry is able to realize new sustainable product ideas and develop these to profitable products in the market. This encompasses both short time-to-market and continuous development and adaption of existing products and processes to improve productivity. Innovative skills are required in both product/service development and in product/service introduction. Thus, there is a need for new innovative methods and models that supports and strengthens industry in generating new ideas and realizing these into successful products and improved processes. This paper discusses and compares engineering design, innovation, and design. The paper argues that there is a need to integrate the disciplines and work practices of innovation and design in the engineering design field and to build multi-disciplinary environments to be successful – in research, education and in industry. A conceptual framework for innovation and design inspired product realization is presented in the paper.

Keywords: Engineering Design, Innovation, Design, Product Realization, Multi Disciplinary Research

1 INTRODUCTION
The competition is becoming truly global with fragmented markets and customers expecting to get the best product at the best price with immediate availability. In this business environment change and uncertainty dominate. Economic growth and future jobs are dependent on how present and future industry is able to generate ideas as well as work with product realization.
In an *era of open innovation* [1] and *democratizing innovation* [2] today people from inside as well as outside companies are inspired to develop and implement their ideas. Successful companies as Proctor & Gamble, 3M, LEGO and Google are examples rethinking the fundamental ways in which they generate ideas from both outside and in-house R&D. Global and special web sites for open on-line marketplaces in problem-solving, idea exchange and innovation are growing.
The ability to use and develop knowledge and creativity is considered to be the major strategic factors for future competitiveness. Significantly, knowledge and creativity are not just additional production factors alongside the traditional ones. These are the most meaningful and important resources for innovation and product realization in a company, its innovation capacity to meet demands of uncertainty, flexibility and creativity [3].
In summary, there is a need for new innovative methods and models that will support and strengthen industry to generate new ideas and realize these into successful products, services, and improved processes. Also, the gap between academic research and industrial practice has to be bridged [4]. This can be done by developing tools and methods based on well-known and familiar design methods [5].
This paper argues that product realization based on engineering design is not enough. It is becoming more and more important to build bridges to other disciplines as "innovation" and "design" and to build "multi-disciplinary" environments to be successful in business and in research. The objective of the paper is to discuss how different disciplines and work practices can merge to create better products, processes and services and what it requires from participating actors concerning flexibility, openness, communication skills and changes in mindsets. A conceptual framework for innovation and design inspired product realization is presented based on review of literature as well as the analysis of two research projects. The results in this paper are discussed in relation to Mälardalen University in Sweden and an ongoing effort to build a multi-disciplinary academic milieu.

2 METHODOLOGICAL ASPECTS

This paper is based on both a literature review, as well as the review of two projects that have been used to collect data. The two research projects have been carried out over a relatively long period of 4-6 years, where researchers from different universities as well as practitioners from many companies have influenced and evaluated the process, the results, the final findings and the future use together.

3 LITTERATURE REVIEW

This section discusses and compares engineering and product realization in relation to other disciplines and work practices as innovation as well as design. Integration between engineering, innovation and design is discussed as an important future development within academia and industry.

3.1 Engineering and product realization

The product realization process could be considered as a process of transforming different stakeholders' needs into output information, which corresponds to a manufacturing good design, see figure 1. This process includes e.g. scenario planning, idea and technology management, product planning, product development and production development including logistics, maintenance and recycling. The problems with implementing an efficient product development process can generally be explained by the high number of different phases, and thus disciplines, that all have to collaborate [6].

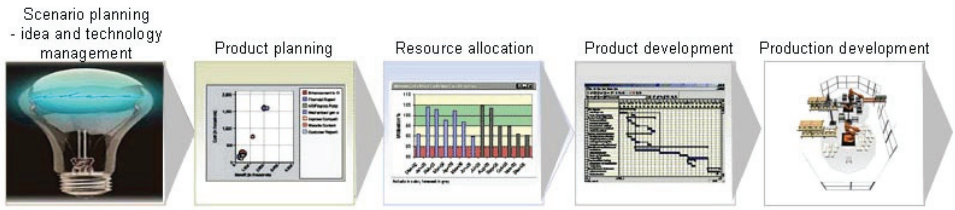


Figure 1. The product realization process

A large amount of information has to be coordinated in the product development process. An efficient organisation also has to understand the information processing logic and the integration with its environment which requires communication and coordination skills. These skills are needed to manage and control the complexities of the design process, where activities should be carried out 'concurrently' [7]. One important aspect of coordination is how to manage the overlapping of coupled product development activities.

The product development process needs to be flexible in order to continuously adapt to new demands and to take new product related information into consideration. The product development process is often complex, and might be better viewed as networks. Horizontal and vertical integration is used in order to minimise costs, allocate resources and share risks. Horizontal integration tends to be used for complementary technology/knowledge, and vertical integration tends to be applied for cost reduction.

Product development and engineering science is often described as the development and design of new products based on problem solving. Research within the area has its origins in systems theory and the design science paradigm influenced by e.g. Hubka and Eder [8, 9]. This view is based on an analytical approach which is central to the professional identity of engineers and engineering research. The ultimate goal is to arrive with an economically produced product quickly to the market. The key to do so, for most of producers, have been to work through a chain of decisions by first establish clear objectives of the product, identifying the target market segment and trying to systematically determine the customers wants or needs. Structured design methods have been developed by e.g. Pahl and Beitz [10], and Ulrich and Eppinger [11].

Success factors within product development are extensively discussed in literature. One such study by Balachandra and Friar, is based on an extensive survey and mapped success factors in literature [12]. The major categories found were market, technology, environment and organization. The most critical factors were found in the organization category. Other authors have addressed critical factors of product realization that must be managed which are executive direction, project team, innovation strategies, internal factors, and external factors, etc [13].

Further, the typical characteristics of the product realization for integrated products, which have been winning abilities for Japans world famous production philosophy – ´Toyota Production System´ [14]:

- A focus on short lead time in product development by minimizing waste and a concurrent engineering.
- By higher productivity more development project are possible with the same allocation of resources.
- The development teams are generally smaller and the multi-skilled team members have broader responsibilities and broader perspectives on the project. The Toyota-specific 'Product managers' with very strong mandate and broad competence from market to production leads the development teams.
- Close collaboration between product engineers and production engineers builds a basis for efficient product realization and short lead times.

Worth noticing is the absence of pointing out the formal product development processes as a winning ability. Still, many companies in the western world have attempted to standardize on focused product development methodologies. As a consequence, research within product development is often focused on a technical engineering perspective and is manifested in descriptive and normative models for product development. One analysis of the Toyota product development system is done based on a socio-technical system model with three sub-systems 1) process, 2) people, and 3) tools and technology [15]. In lean product development these three subsystems are interrelated, interdependent and have impact on an organization's ability to achieve its external purpose.

We argue in this paper that, especially for development of integrated and complex products (which will be the most promising path for high-cost nations), it is not enough with traditional subject-specific development processes. It thus is becoming more and more important to address a multi-disciplinary approach incorporating various competences. The next sections describe and discuss innovation and design as two academic disciplines and how we can benefit from this knowledge in product realization.

3.2 Innovation

Technological excellence by itself is no guarantee in a dynamic and growing economy. On the open world market today with free access to new and advanced technology, this must be linked to other competencies in the development of new technology, which can improve productivity and create competitive advantage. The connecting links are innovation and design, where creative, questioning, different and flexible thinking is characteristic [16].

In the knowledge and complex network society we also need to know how to use information in an appropriate way and create good communication methods to understand where to look, what and how to do and for whom. A communicative leadership in our times value-creating networks will be a high competitive factor [17]. And innovation depends also as engineering on organizational, social, economic, marketing and other knowledge. Today even the nature of innovation is changing in the knowledge-based economy, or *the innovation economy* [18]. This year of 2009 has been proclaimed as *year of creativity and innovation* by the European Union.

The reason why individuals and companies invest money, time, and effort in innovation activities is of course that they believe that it will be profitable, that it will result in improved competitiveness and that it will give opportunities to a better life. The fact is however, that society, even more than the inventor, entrepreneur or innovating company, usually is the big winner in terms of growth and development, by impact of innovations as value creators. And this is not only by the first introduction of an innovation as the first mover advantage, but also – and even more – by the followers, the second mover advantage.

The terms innovation, entrepreneurship and entrepreneur were introduced – even if these words had been used before – in a macro-economic and scientific context by Schumpeter in the 1930^{ths}. He focused on innovation and the role of entrepreneurship as an act of *creative destruction* that, by introducing new products and processes, increases productivity and promotes economic growth [19].

The discipline of innovation is based on a dynamic and multi-scientific approach with its own theory, practice, research communities, scientific domains and journals to create knowledge and value in organizations, societies and nations. Some examples are The International Schumpeter Society (ISS); MIT Press Innovations; Journal of Product Innovation Management; Creativity and Innovation Management Journal; Technovation.

Innovation and creativity are probably the most powerful sources of the human intellect. It is only through them that all worlds of art, science, and technology are conceived and ultimately realized.

Creativity is the mental processes about how new ideas and new combination of existing ideas are shaped. There are several definitions today of the term innovation. Innovation is about channelling ideas into producing and implementation of new products, services and processes and/or combination of these to value-creation on the market, in an organization or in the society as a whole. Innovation represents the core renewal processes in any organization. The perceived change can be in small incremental steps – doing what we do, but better or new to the company – or in a more radical way – new to the world. Most innovations are incremental. Here in this paper innovation is defined as the introduction of a new or considerable improved product, service, process, organization or some other value-creating solution in the society. Rather often innovations are combinations of products, services etc. One example is the mobile phone. In our own research and education of innovation we feel alliance with the R&D on innovation at SPRU at University of Sussex and the Freeman Centre with the work of Tidd, Bessant and Pavitt [3], and also with MIT Sloan School of Management with Utterback [21] and von Hippel [2].

Research on product realization from an innovation approach shows that most products, services and processes – when implemented as innovations or technological breakthroughs – will soon or later come into a stage of *dominant design.* This is a stage when more and more companies work more and more competitive within the same product range. In such stages the so called second movers or followers will compete on incremental improvements, their productivity, cost reduction and services then on the novelty or innovativeness of the product. However many of them fail in short or long term if they are not open – in time – to the changing needs and even latent expectations in market trends [20, 21]. Figure 2 states that the rate of major innovations in technology for both products and processes follows a general pattern over time and that product and process innovation share an important relationship.

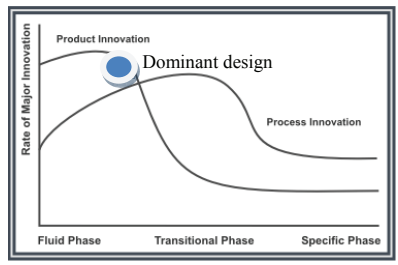


Figure 2. A model of product and process innovation over time [21]

In the dominant design model product related innovations prevails over process innovation. The market contenders are a growing number of small as well as large companies pursuing competing product concepts (fluid phase). But typically, the market prefers one of the product concepts which establish itself as a dominant design. During the emergence of dominant design, competition between companies shifts from product to process innovation (transitional phase). Those companies unable to make this transition will disappear. Only a few companies will remain in the market, when technology has reached a mature stage (specific or rigid phase) [21, 22].

Unless a business is prepared to work continuously at renewing what it offers, and how it creates and delivers that offering, there is a good chance that it won´t survive in today´s turbulent environment. No companies have guaranties of survival and even whole industries can be undermined and disappear as a result of radical innovation which rewrites the technical and economic ´rules of the game´ [20, 21]. As an example of this is that only one firm out of the Dow Jones 100 index actually survived from the beginning to the end of the 20th century [23].

Another dimension of innovation processing raises the question of how ´problems´ should be defined when consumers, customers or clients not yet have imagined a product they do not yet know, and engineers are not sure what they can build. At least in the early stages of product development, it is not possible to have a clear set of objectives for the project, no matter how carefully you listen to the customers or client's voice. You simply do not know for certain how the new technology would be used. As an example, the use of mobile phones was first expected to be used only as a car-mounted device. Most innovations can't be identified from the beginning with a clear address to a particular need or problem. The problem and possibilities became apparent after a while or even after the

product was in use. In this uncertainty, the innovation approach is more like a random process, ad hoc, a matter of trial and error and an open-ended process in contrast to a formal and analytical product development processes. Opportunity finding is more in focus in innovation practice than in engineering, where, as discussed in previous part, problem solving is more in focus. In total the sources of innovations are many and result from a conscious, purposeful search within a company or an organization for opportunities like unexpected occurrences, incongruities, process needs etc. Outside the company in the social and intellectual environment exist additional sources of opportunities like new knowledge and new technology, changes in people´s needs, values and perception [24].
But how can approaches from engineering and innovation bee integrated in product and process realization to fulfil the high demanding customer and user? Do we need a different and more open-minded approach without boundaries in creating collaboration, forming teams and combining knowledge from several fields? We will discuss these challenges later, but first we need to look at design approaches and design science as a third force in a our proposal to an integrative view on product realization.

3.3 Design

Design can be described in two distinct ways – by reference to the process of design or to the product that has been designed. The former can be named designing and is often described as an iterative process in which need, or problem, is understood as the solution that is generated and evaluated [25]. Design is a goal- and action-oriented activity – with professional tools to visualize our thoughts and our creativity into something useful, sometimes elegant and perhaps also tells us a message. For products realized today it is not sufficient with good function, form and aesthetic appearance. The product must also emphasize simplicity and economy of means and low impact but also tells us a message we can identify ourselves with. It could be a music player, a car, a piece of furniture, spectacles or a wheelchair.
If a product is apparent, simple, and clear, it will stand out from all of those competing for our attention. Design is about of understanding the users´ need, the product´s message (what story the product tells) as the deeper wishes, values and emotions. The design of the product itself, the information design, the interaction between the user and the product etc is essential for all products today, when the complexity increases for the user.
Today designers are ´innovators´ too. An example is the *Quarterly Journal of Industrial Designers of bild Innovation America,* which since some years has the name *Innovation*. Designers also get higher scope and greater execution responsibility in the corporate strategy of their clients and even sometimes take over the innovation processes as outsourcing, see figure 3.

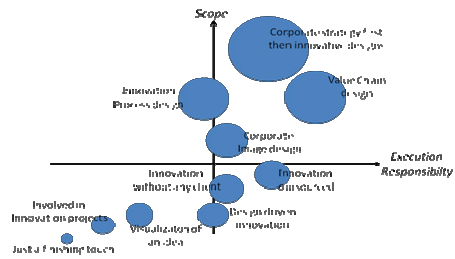


Figure 3. Design avenues to innovation [30]

Successful companies do always include designers from the beginning in a new innovative product development project. The design firms work more and more in value-networks, where the designers act like ´brokers´ or ´mediators´ between other companies within material technology, tools for design, innovation, product realization etc. [29] Design occurs in engineering and in many other domains as diverse as textiles, software, information, and architecture. We recognize these activities as similar, but it is often difficult to say what actually is similar and different [25]. No company trying to realize new products can underestimate the great importance of design from the start to the market introduction.

3.3 Integration of engineering, innovation and design

Previous sections have discussed needs and challenges in relation to the exploitation of new ideas into successful products, processes, and services on the market. There are several areas which need to be mastered in order to have a competitive development process as e.g. coordination and integration, people and creativity, efficient tools and technology, visualization of ideas, organization of the development work etc. It has also been stated that innovative products gives companies a competitive edge that allows them to charge a premium – which creates higher margins. A conclusion is that integrating engineering, innovation, and design is proposed as one necessary future development for industry and academia.

A multi disciplinary approach towards product realization is not a new phenomenon. Most innovative products and services spring not from particular industries or disciplines, but rather across them – the so called *Medici Effect* [26]. Medici referring to the Medici-family in Italy in the Renaissance period, who sponsored people from different disciplines and made Florence to an epicentre, an intersection and one of the most creative eras in Europe´s history. This intersection can also today be a place – a milieu – where ideas from different fields, disciplines and cultures can meet, leading to new ideas, new products and to innovations. Then a multi-dimensional approach is necessary, where engineers, designers, entrepreneurs, psychologists, economists and many more collaborate. Successful companies have implemented such a work practice.

Still, the historic model of university has led to a disciplinary structure which does not encourage a multi-dimensional approach. This is evident even though practice over and over again shows that practical applications is increasingly cross-disciplinary, or even are becoming interdisciplinary. There are a number of attempts of building academic multi disciplinary organizations, but it has by no means become a general education and research model. The university should reflect on the structure of the natural world and of the man-made world to promote integration across fields [27].

A similar view on the importance of integrating practice is argued by Andreasen, who talks about the importance of work-practice as the starting point within design science research [28]. Design science research should start with the study of work practice based upon theories. Following this, contributions to theories and design knowledge as well as the improvement of practice can be done.

It is evident that a disciplinary structure in academia does not go hand in hand with a close connection to and study of work practice. An interdisciplinary approach within academia would be more helpful, looking at practice from different angles. Such an approach would get much more involvement from industry stimulating cooperation and co-production of research. With this reasoning, the intersection mentioned as a *Medici Effect* is not only a bridge of disciplines but also a bridge between academia and practice. An overall goal would be to create an academic research and education milieu that master multidisciplinary research, which integrates not only different disciplines but also work practice.

An example of an approach towards integration of engineering, innovation, and design is the company IDEO, probably one of most distinguished design and innovation companies in the world. This award winning firm has developed an innovative culture that has generated many different innovative products using design and creativity. If we should learn from best-practice in the case of IDEO, an interdisciplinary approach is the right strategy. Looking at the methodology that IDEO uses it is evident that e.g. design/visualization and border-crossing is vital to competitive product realization. The methodology that is used has five basic steps [29];

1. Understand the market, the client, the technology, and perceived constraints on the problem.
2. Observe real people in real-life situations
3. Visualize new-to-the-world concepts and the customers who will use them.
4. Evaluate and refine the prototypes in a series of quick iterations.
5. Implement the new concept for commercialization.

4 TWO EXAMPLES OF RESEARCH PROJECTS

Two research projects of different approaches and methods – where the authors of this paper were participating – is discussed and analyzed as examples in this paper. These two research projects are named; *Factory-in-a-Box* and *Design Inspired Innovation.* Both projects have been presented earlier in scientific articles and in two books. We will use these findings as a platform for a discussion on how

and what to integrate into product realization. The aim with this analysis is to test and revise some of the statements concluded in the literature review.

4.1 Factory-in-a-Box

In January 2005, the Swedish Foundation for Strategic Research started a research project called "Factory-in-a-Box". Factory-in-a-Box was the final project within an extensive research program, called the ProViking program. The Factory-in-a-Box concept has the key characteristic of a modular production unit that is flexible, mobile and quick to ramp-up. The Factory-in-a-Box concept has been developed, exemplified and realized in five industrial demonstrators developed by researchers together with competitive manufacturing companies in Sweden, such as ABB Robotics and Bombardier.

The Factory-in-a-Box concept consists of standardized production modules that could be installed in e.g. a container and transported by e.g. truck or train. The modules can then rapidly be combined into production systems that can be reconfigured for a new product and/or scaled to handle new volumes. Production capacity may be provided as a mobile and flexible resource that rapidly can be tailored to fit the needs of a company, at a specific point of time. The emphasis on mobility in the Factory-in-a-Box concept is important in Sweden, where geographic limitations are a reality.

A number of application fields for mobile manufacturing were exemplified in the project, and a number of advantages of mobile manufacturing were identified. Even if this was a first step to describing and developing the concept of mobile manufacturing, there are strong indications that mobility is going to become a competitive mean in future manufacturing industry. Instead of investing in new equipment, manufacturing equipment could be shared between companies. This is advantageous in several cases, such as when the manufacturing equipment is expensive but not frequently used. There is also a possibility for small companies with limited resources to make joint investments in expensive manufacturing equipment. By using mobile manufacturing it is possible to implement fully automatic equipment and thus to remove manual operations that are work environmental disadvantageous. Moreover, by using mobile manufacturing capacity, the same capacity can quickly be moved between manufacturing departments or sites within a company and the overall equipment efficiency is thus maximized.

Analyzing the Factory-in-a-Box project in retrospect a number of challenges and success factors can be identified having impact on the success of the development of this concept. First of all, this project was focusing on building demonstrators in close cooperation with academy and industry. The project teamed resources from different research groups from several universities as well as from industry. The interdisciplinary research team and industry partners had competences in the fields necessary to design and build technically and economically feasible industrial demonstrators. This was a precondition for achieving successful implementation of new research.

The fact that the demonstrators were developed and built in real industrial settings gave the opportunity for border-crossing research with high involvement from industry. The project was based on the study of work-practice trying to develop and improve current processes, from idea to final implementation. The importance of co-production as well as the earlier discussion on work-practice as the basis for design research was very evident in the project.

The Factory-in-a-Box concept was (is) an innovative production concept and the visualization of the concept in order to communicate the vision between different actors was very important. Similar to the discussion on IDEO, visualization and creation became crucial in order to divide up the work between the different actors. Much focus in the project was on events, demonstrating results. This helped keep focus in the project, as well as build a common understanding.

Much time was spent in the project to brainstorm and create ideas on how to realize the concept. Creativity from individuals and within the group was a very important first step as in any development project. In this case, an overall concept had first been described and decided upon. The focus in the project was on how to realize the concept in the industrial settings. Help from creativity consultants at different work-shops proved to very helpful and time saving.

Some of the challenges or mistakes in the project that we can learn from are the difference between problem solving in relation to opportunity finding. The Factory-in-a-Box project was very much an opportunity finding, a new concept, not based on an existing problem. This difference in mindset was a challenge, especially from a traditional engineering point of view. The innovation mindset and paradigm was very important for success, and maybe this could have been organized in a better way from the beginning.

Finally, one area proven to be difficult in the project was communication and team building in the distributed project team. This is by no means new or special for this project. The importance of having meetings, to sit together and build a team spirit in the project is very important in an innovative development project.

4.2 Design Inspired Innovation

The purpose of the project Design Inspired Innovation was to explore the ways in which communities of art, design, and innovation are merging and influencing each other in a world of material culture to create great new products. The questions were: What makes products great? What is the role of design firms in creativity and innovation, and how is this role changing? What accounts for design firms´ successes? How are the processes of innovation and design changing? Does a focus on design inspire innovation and enhance chances of competitive success? What strategies might result in more inspired design and innovation?

The results of a study in 2001-2006 explore these questions, which included visits and interviews with firms and their founders of nearly 100 design firms in four countries – Sweden, Italy, England and the United States – and in several industries. The sample ranged from three divisions of the largest international design firms to small and new firms. Some of these were IDEO, Design Continuum, DEKA Research, MIT Media Lab, Synetics, Product Genesis, Walt Disney, Artemide, Flos, Alessi, LEGO®, ErgonomiDesign and Propeller. The contributions were broad to advancing innovation and design in several types of products, including consumer electronics, devices for personal mobility, and others.

The international research team consisted of three engineers of different background, one designer, one sociologist, one economic geographer, one ergonomist – in five different universities in the four countries, Massachusetts Institute of Technology, University of Manchester, Politecnico di Milano, Rensselaer Polytechnic Institute and Mälardalen University. The members of the research team all work with innovation management, product design or product development today. We shared our findings and analyzes in workshops together with design firms at international conferences. We had a close cooperation with engineering, design and innovation students at Mälardalen University in Sweden and at Massachusetts Institute of Technology.

Great products with ´dominant design´ are those that have grown in meaning and value over their – and generations of users´ - lifetimes. They capture our hearts and make our lives easier, better, or more interesting. In the merging processes of technology-innovation-design three types of knowledge are essential. It is knowledge about the user needs, technological opportunities, and product languages. The last component concerns the signs that can be used to deliver a message to the user and the cultural context in which the user will give meaning to those signs. It is about the product´s emotional and symbolic value, see figure 4.

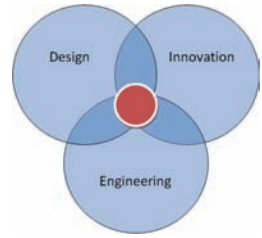
Figure 4. Design as the integration of technology, needs and language [30]

We concluded that products, to be successful must be distinguished by more than sufficient function, consistent quality, and low cost. Our findings and examples implied that considerable competitive advantage might be gained by reconsidering traditional products with a fresh eye and approach that employs newer materials and design techniques. Why do only a few of the welter of products on the market seem to account for the bulk of sales and profits in many categories? We believe it is because these products emphasize customer delight, elegance, and enduring value. They may even acquire increasing value over time.

It was obvious results in our study that the communities of innovation, technology, art and design today are merging. The boundaries seem to be more blurring to meet these new challenges and also to broaden human possibilities with more user friendly and meaningful products, whether the products are professional tools, machinery for production, daily consumer goods, or services. It also requires – what was obvious in the larger design firms – that the teams included several different competencies

as designers, engineers, psychologists, sociologists, economist/marketing, linguists and ergonomists. Based on the literature review as well as on the two examples of research projects a conceptual framework for innovation and design inspired product realization will be presented in the next section.

5 A CONCEPTUAL FRAMEWORK FOR INNOVATION AND DESIGN INSPIRED PRODUCT REALIZATION



This paper has argued that it is becoming more and more important in successful product realization to build bridges between disciplines and to build multi-disciplinary environments to be successful in business and in research. Three different disciplines have been identified as important to merge in order to build competitive development skills; engineering, innovation and design. The objective in this section is to develop a conceptual framework for innovation and design inspired product realization based on both literature as well as the analysis of the two research projects.

The models to understand, describe and deal with such a multi-discipilinarity of innovative activities are many. [31]. Previous and often used models as ´the black box´, linear models as the ´technology push´ and the ´market driven need push´ are not quite appropriate anymore. The linear or sequential models have been deeply questioned, because of an oversimplification of innovation and product realization processes. A need for more interactive models is obvious. An integrative model (figure 3) where design, engineering and innovation can interact is where the innovation process can be thought of as a complex net of communication paths, both intra-organizational and extra-organizational, linking together the various in-house functions and linking the firm to the broader scientific and technological community and to the market place, see figure 5.

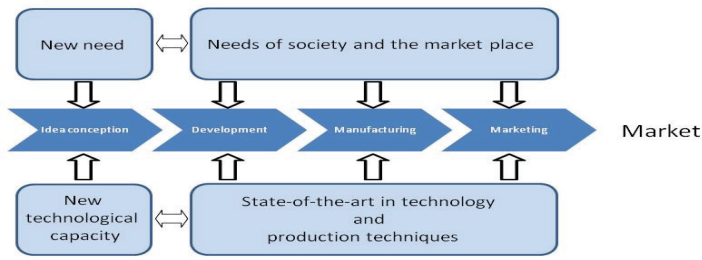


Figure 5. An integrated model of product realization [31]

In such an interactive model, innovation is no longer the end product of a final stage of activity but can occur at various places throughout the process. It can also be circular (iterative) rather than sequential. This model can include feedbacks and loops allowing potential innovators to seek existing inter- and intra-firm knowledge as well as carry out or commission additional research to resolve any problems arising from the market-design-production-distribution process.

Based on earlier discussions in this paper the following disciplinary areas in design, innovation and engineering are proposed as important to include when developing an innovation and design inspired product realization process. Of course we could have included several more characteristics, but we have here simplified, made our own choice and focused on the nine, we have found be most relevant;

Design	Innovation	Engineering
Design thinking, interpretation and visualization	Creativity and idea generation	Enabling technologies
End user perspective and focus	Opportunity finding methodologies & mindsets	Problem solving methodologies & mindsets
Holistic view on the product	Communication – internal and external in networks	A structured product development process

1. Design thinking, interpretation and visualization

Successful external cognitive tools compensate for limitations in human memory and information processing, at the same time that they take advantage of them. The creativity is enhanced by allowing designers to interpret sketches. The designer views this as interacting with the sketches as in a

conversation [32]. The designers see more in their sketches than they put in when they drew them, and these insights drive further designing.

2. End user perspective and focus

As for example argued by IDEO the end user should be incorporated in the development work. This means that it is important with e.g. ethnographical studies of customers. It is important to understand the market, the client, the technology, and perceived constraints on the problem.

3. Holistic view on the product

Designers have always – when they are included in a project from the early stages - a holistic view on the product and the use of it. This is a characteristic of ´the industrial-, product- and information designer´s soul´ and differs from the engineering designers who focus more on the technical components and function of the product [33].

4. Creativity and idea generation

Creativity is one of the fundamental sources to innovation and entrepreneurship and the necessary basic source to implement an innovation to be successful in reality. Creativity and innovation is more connected to divergent thinking which is characterized by intuition, curiosity and uncertainty.

5. Opportunity finding methodologies and mindsets

To have an opportunity mindset and not only focus on problem solving is what characterize the innovation discipline and practice. Opportunities open up for creative work, creating something new, not only more of the same.

6. Communication and networking

All kinds of communication have to be effective and efficient. First of all, an external representation can carry understanding in multiple interpretations, in terms of creating a common mental image in the project. Communicating this mental image between different parts in a development process is hard and demands a dialogue that does not flinch for analogies and metaphors, and that the receiver interpret from his or hers experiences.

7. Enabling technologies

Enabling technologies are of course one of the basis for product development and innovation. Technological breakthroughs will come into the stage of *dominant design,* where more and more companies work more and more competitive within the same product range. Enabling technologies include technologies connected to the product design as well as technologies necessary for development. Tools and methods for analysis and evaluation are also important.

8. Problem solving methodologies and mindsets

Product realization is based on the development and design of new products often originated from problem solving. Based on existing needs and requirements, the ultimate goal is to arrive with an economically produced product quickly to the market. Problem solving is initiated by working through a chain of decisions by first establish clear objectives of the product, identifying the target market segment and trying to systematically determine the customers wants or needs.

9. A structured product development process

The design process is a model for the application of design in product development. It is part of the company's entire development process and is used to achieve successful, creative results through the medium of design skills and know-how. The design process can be applied to many different areas and projects that concern processes, messages, goods, services, production or environments.

In our conceptual framework a holistic view is necessary to be competitive and successful when developing new products, services and processes. Both organizational – and management – innovative thinking is essential, because it is people with their creativity, motivation and knowledge who make the difference and the power of development.

6 DISCUSSION AND CONCLUSION

The notion that it is important to bridge and unite different disciplines to improve product realization capabilities is not new to the research community. Still, there are today a lot of discussion on academic excellence and if interdisciplinary research really contributes to new knowledge. Also, the question how to organize and actually get people to work interdisciplinary is a challenge and something worth discussing. It is not sufficient to only organizing everything into large departments or institutions. There are many more obstacles to overcome as for example the different view on research methodology, the different views on the research object, and the different expectations on the research results. One could speculate that it would be very important to justify why interdisciplinary work is

needed based on a common vision and strategy. Also, having the flexibility and balance in an organization to allow and embrace differences in knowledge and views at the same time promoting in encouraging cooperation.
A question is if we should aim for a new research paradigm within for example design science where we integrate more and more disciplines? Or is there a risk that design becomes too broad and loses its identity? What should be the basis for integrating disciplines, on what premises?
We propose in this paper that the key and reason for interdisciplinary research is the common view on the research object. We support the ideas that research within product realization should be based on work practice, and it is the work practice that we in the end want to improve. Based on this view point it would be very important between academic and industry cooperation and coproduction. This is one of the main enablers for successful research.
To support the development of the next generation products and services within industry, we conclude that there is a need to develop and implement new innovative methods and models that will support and strengthen industry to generate new ideas and realize these into successful products and improved processes. It is not enough with an analytical and traditional engineering based approach towards product realization. Instead industry must address areas as e.g. innovation, design, multi disciplinary team and environment, teamwork and collaboration. A conceptual framework for innovation and design inspired product realization has been presented based on review of literature as well as the analysis of two research projects.
Based on the discussion and conclusions in this paper we are trying to build a multi-disciplinary milieu in practice as well as implementing an innovation and design inspired product realization process at Mälardalen University in Sweden. Our "milieu" is focusing on Innovation and Product Realization (IPR) and is an attempt to create a multidisciplinary "education and research" environment. It consists of different research groups within Product- and Process Development, Innovation Management, and Information Design. These three "academic partners" work closely together in an ´intersection´, where ideas from different fields and cultures meet, leading to new ideas and possibilities. It is not a ´marriage´ between our disciplines, but more of understanding, collaboration and using our different mindsets, knowledge and scientific methodologies in a value-creating way for the research community and for the industry. IPR was established in Eskilstuna in 2001 and has since then expanded and worked actively to become an established group within the region of Mälardalen and on a national level. IPR consist of three main parts.

1) A multi-disciplinary milieu, physically located in Eskilstuna, Sweden.
2) A common research theme within Innovation and Design Science, where a ´new´ working methodology will be created.
3) A Centre for Product Realization where projects and co-production with industrial and other partners are initiated and supported.

We are within IPR trying to build bridges between disciplines as "engineering", "innovation", and "information design". We believe that the different disciplines and work practices can merge to create better products, processes and services and what it requires from participating actors concerning flexibility, openness, communication skills and changes in mindsets. By implementing a framework for innovation and design inspired product realization in combination with increased cooperation and coproduction with industry we believe that it is possible to achieve academic excellence through the contribution to theories and design knowledge as well as the improvement of practice.

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