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Prototyping Revisited

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Abstract
Until now, prototyping has been developing as a technological discipline. In so it has proven to be a strong means to test specific solutions or physical designs before the launch of a product. The results have been reduced development time and improvement of quality in a broad sense. There are, however, indications that we should review our perception of prototypes to be broader and to view our application of prototypes in a broader organizational view. This paper presents an initial and explorative review of the changing role of prototypes in product development.

Keywords: Prototypes, Typologies of Prototypes, Bias for action

Introduction
Peters & Waterman made one of the last century's best accredited business books in 1982, *In Search of Excellence* [1]. The basic idea of the book was to portrait some of the best performing American enterprises and to summarize this into 8 recommendations for enterprises in general.
In 2002 at the 20 years anniversary of the book Tom Peters were given a chance to comment on the book and in particular to comment on their recommendations. His comment regarding the recommendations was,"*Some I'd drop today. Some I'd modify. And one – just one – I'd underscore. Our number one idea has held up! To wit: a bias for action.*"
The driving idea behind our study has been to explore the impact on product development processes when this *bias for action* is practiced more seriously in industrial enterprises. In many ways most companies have had some prototyping activities but it is our experience that the importance of these activities has increased in the past few years.
In this paper we will discuss this phenomenon in general and provide an example from the Danish enterprise Bang & Olufsen.

Bias for action and learning
In 1984 David Kolb published his book title "Experimental Learning" [2]. His claim is that we are learning by cyclic patterns of four types of activities: Concrete experience, reflective observation, abstract conceptualization, active experimentation (see figure 1). According to Kolb it does not matter where we start - the important requirement for real learning is that one goes through the full cycle.
Though Kolb's work is aiming at the individual level there are several contributions supporting that a similar pattern is valid at the organizational level. Dorothy Leonard argues that: "The primary activities spawning organizational learning are experimentation and

prototyping" [3] and Argyris and Schön [4] has introduced the notion of single-loop and double-loop learning which includes active experimentation. In his classic Harvard Business Review article, "Creativity is not enough" [5], Theodore Levitt offers the following analogy: "Suppose you know two artists. One tells you an idea for a great painting, but he does not paint it. The other has the same idea and paints it. You could easily say the second man is a great creative artist. But could you say the same thing about the first man? Obviously not. He is a talker, not a painter." Based on this story, Levitt says that brilliant talk is very often mistaken for constructive action

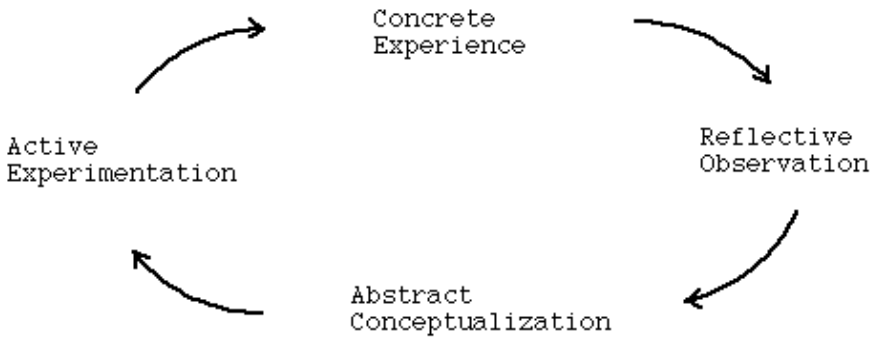

Figure 1. David Kolb's learning circle

Donald Schön has been studying how professionals are working very differently from novices. His point is that when people have reached a certain level of professionalism it will change their working style and become "reflecting practitioners" [6]. The reflective practitioner is in a constant process of thinking, reflecting, acting, and building experience – very much in line with the learning process as described by Kolb. This process is efficient for the professional person but due to the amount of tacit knowledge it is often difficult to articulate and share the results with others [7]. Physical models or other model representations seem to be the most efficient means to facilitate this sharing (and learning) process [6,8].

Bias for action and decisions

Decisions are central and necessary elements of any development and design process. Our traditional perception of decisions as a result of an analytical process can not be verified by empirical research. A more trust worthy model is proposed by March [9]. According to March problems, solutions, and decision makers are in a constant flow around the organizations. On some occasions decision opportunities emerge when decision makers, problems, and solutions are present at the same time.

Figure 2. The Garbage Can model of decision making [9].

The model has been named Garbage can model because decision makers, problems, and solutions are in a constant flow that occasionally meet when decision opportunities arise.
It is thus important for an organization to facilitate an environment where decision opportunities emerge frequently during for example a product development process.
Physical prototypes have proven to be excellent facilitators for such purposes [8].

Bias for action and management involvement

Top management in various companies have different biases for involvement in the initial phases of product development processes. This is an often observed empirical fact even though the same empirical surveys show that top management involvement is one of the strongest differentiating factors between success and failure projects [10].
Wheelwright and Clark present an empirical based model of the management involvement in product development project (see figure 3) [11]. As the model shows, management involvement peaks when prototypes are made. Making the right decisions as early in the process as possible is crucial, and can be facilitated by producing an abundance of prototypes.

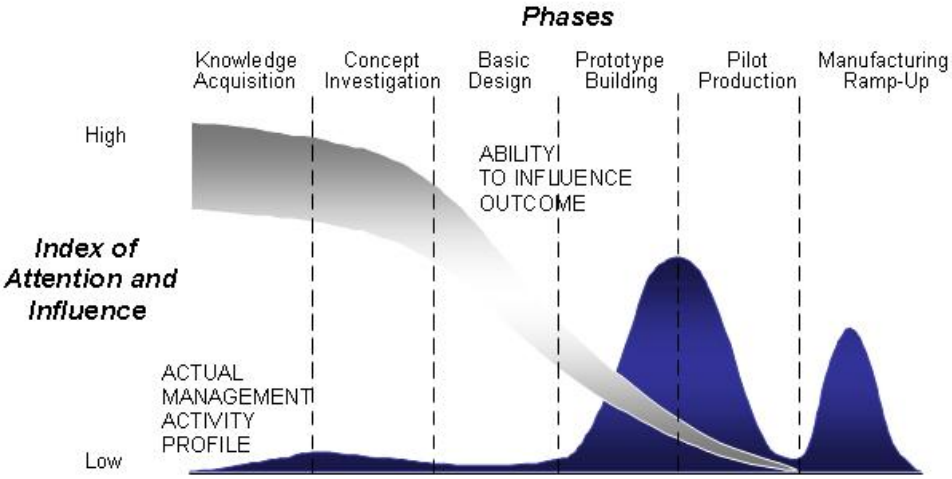

Figure 3. Management's opportunity for and actual exercise of involvement [11].

Smith and Reinertsen acknowledge the observations made by Cooper, Wheelwright and Clark and argue that we have to change our perception of prototypes. They suggest that we should change our perception of prototypes from being a technical tool to being a business tool [12].

Bias for action as a strategy

In his book, Serious Play, Michal Schrage [2] praises many aspects of prototyping for speeding up processes etc. and mentions examples of great breakthroughs made by new prototyping tools. The following extracts provide exemplary viewpoints form the book:

- When talented musicians improvise, you don't look inside their minds; you listen to what they play. When talented innovators innovate, you don't listen to the specs they quote. You look at the models they've created.
- The challenge of converting uncertainty into manageable risks or opportunities explains why serious play is often the most rational behavior for innovators.
- Serious play is about improvising with the unanticipated in ways that create new value.
- Prototypes engage the organization's thinking in the explicit. They externalize thought and spark conversation.
- Prototypes force confrontation with the tyranny of trade-offs.
- The conventional wisdom that "innovation processes" drive prototype development is misleading. Empirical observations of organizations with effective innovation cultures confirm just the opposite: changes in prototypes and simulations drive the innovation process.
- Prototypes are machine tools for producing choice.
- Most companies have formal prototyping processes and informal prototyping cultures.

Schrage agues against the common assumption that "great teams make prototypes" and suggests that instead one should realize that "prototypes make great teams". The making of great teams goes beyond the individual team, but helps create teams out of people with different backgrounds by creating "shared space". Shared space is the common ground where people can meet on even terms and objectively discuss matters.

Bias for action and different types of prototypes

Prototypes might be virtual or physical. They might cover the whole product or only selected elements. Ulrich and Eppinger have suggested a classification of prototypes (see figure 4) [13].

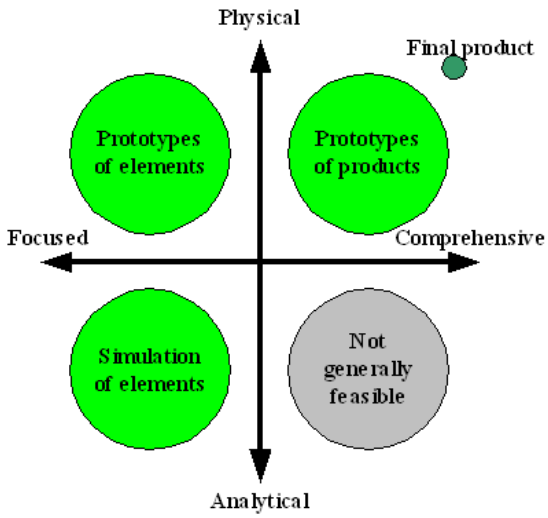

Figure 4Classification of types of prototypes [13]

The physical prototypes attempt to present a natural view of the product. The analytical prototypes are often mathematical models of the product that enables analyses and experiments. The focused prototypes cover one or a few elements of the product and can be useful to test critical features.

Bias for action and an iterative interaction practice

Bob Cooper, who is often cited as the father of the Stage-Gate models that can be found in most companies, points to prototypes as some of the strongest means to get user and customer feedback as an integrated part of the product development process [10].
Cooper refers to the fact that "customers don't know what they're looking for until they see it". Thus the message is simply to get something in front of the customer as early as possible – even if it is not the finished product. Only then will the customer have something that he or she can react to and start providing valuable feedback on. Customers seem to have an innate ability to find product weak nesses, things that the engineering-testing group could never have imagined. The ideal action is fast, highly iterative, and parallel; a rapid prototype followed by immediate customer feedback, followed by development of another part of the product or a more complete prototype.

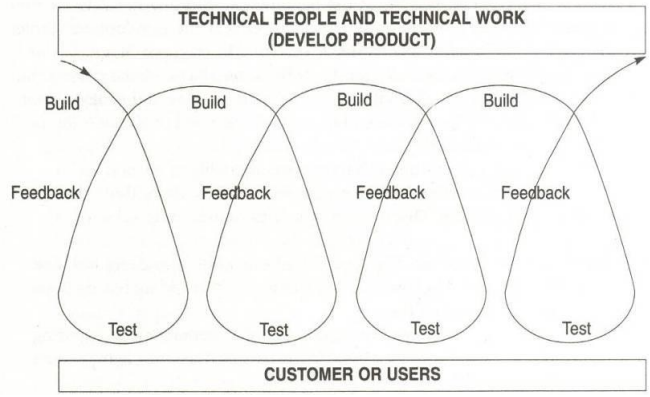

Figure 5. Prototyping seen as an iterative process of interaction between the technical development organization and the user or customer [10]

Methodology

The former represents several theoretical contributions to a broader understanding of the role of prototypes. To support this view we have made empirical research in two Danish manufacturing companies. The research has been conducted as interviews with 2-3 persons in each company. In the following is reported some observations from one of the companies.

Empirical experiences

In the following we will share and discuss experiences from the Danish audio and video manufacture Bang & Olufsen.
Bang & Olufsen (B&O) develops and manufactures audio and video equipment with particular focus on design and on user interface. Most of the production, R&D, the administrative management, and the marketing headquarters are situated in Struer, Denmark. B&O employs app. 2300 people of which the majority works in Struer. In 2004/05 the turnover equaled DKK 3.8 billions, and 80 pct. of sales were exported. The company vision is defined as "Courage to constantly question the ordinary in search of surprising, long-lasting experiences". In figure 6 the most recently launched product from B&O is illustrated.

Figure 6. The Beosound 4 with the Beolab 4 loudspeakers. An example of a recent product from Bang & Olufsen.

Product development at B&O

A traditional Stage-Gate model inspires the product development process at B&O. However, the initial idea-development phase is separated sharply from the rest of the process. During this phase, a few experienced employees generate the first ideas about new products in close cooperation with external designers. When the product idea leaves the initial phase the physical design and the requirements regarding user interface of the product are determined. Often the specified physical design challenges the engineers in the subsequent phases to the level of their capabilities, but rarely design changes have been accepted.

The small organizational unit which handles the initial phase is termed “Idea Land” and it is believed to be one of the main reasons for the continuing financial and commercial success of B&O. Nearly all small competitors have closed down or have been absorbed by much larger companies like Philips, Panasonic, Sony, etc.

B&O has been able to maintain a small niche within the high end of the market and thereby they have obtained significantly higher prices on their products. However, a number of observations indicate that competition is getting fiercer. Some competitors are able to copy the features of the B&O products and launch products at high speed, with a good quality, but at a lower price. Other competitors are challenging B&O by launching products for the same market niche and with comparable product features.

Facing the harder competition B&O focuses increasingly on the overall competitiveness. Unique innovative products are not enough to stay competitive.

One particular challenge is to increase the speed of launch to 3-5 new products each year.

Product development and prototyping at B&O

Historically there has been a strong focus on the application of prototypes at B&O. The designer Jacob Jensen reportedly made 42 prototypes before the launch of BeoMaster 1900 [14]. After that period the number of physical prototypes decreased. 3D CAD and numerical simulation took over a part of the need. The different prototype activities were integrated in the organization and there has not been a formal prototype organization.

However, increasingly there has been recognized a need for a different and strengthened organization of the prototype activities. This is partly driven by the need for more frequent launches and also by the fact that the new products are more technical integrated.

The following case has facilitated the internal discussion of how to reorganize the prototyping activities.

A new user interface

B&O has consistently aimed at combining an elegant design and a clear and logical user interface. In 1999 the external chief designer David Lewis proposed a concept for a new telephone with a dial on a plain aluminum plate. However, there were no available technical solutions. The need was seen as a general need, and consequently, the effort to develop such a solution was intensified.

One particular technology identified was the sensi-touch technology. This is a technology where a given function can be activated by a light touch with a finger without any moving mechanisms. It has been technically possible to have such functionality, but due to the working principals it has required an isolating plate of plastic or glass.

Due to B&O's preferences for applying aluminum there has for a long time been a request from the designers to realize the sensi-touch technology directly on this material.

The first model was aiming at finding the right finger pressure necessary to activate the function and to give to the user the feeling of activating the function. Visible or feel-able deformations of the aluminum plate were not acceptable to the designers. The designers wanted to make the user feel a clear difference when comparing to the soft folio dial as found in many applications.

Figure 7 The first sensi-touch model on aluminum.

The model was built fast of a aluminum plate, a PVS foil, and a beeper. Buttons were only marked with a pen.
The simple model made it possible to have input from independent users and it proved that a finger pressure of 150 grams felt right.

Figure 8 The second version of the prototype.

The model was firstly designed to explore the different sensi-touch technologies. Secondly to test the right area for the activation – this is tested by the different sized buttons.
Again the model was useful as internal tool as well as a tool to get feedback from independent users.

Figure 9 The third version of the prototype..

This time the model was designed as a telephone dial with numbers. To test the input-output relations a simple pocket calculator was connected.
The model was used internally to test and refine the technology.

Figure 10. The fourth version of the prototype.

In this case the model was integrated with a real telephone where the dial was replaced by the sensi-touch dial. Ten models were build and they were placed in the purchase department to have them tested in an environment with a frequent use.

The sequence of tests was successful. However, in the meantime the telephone that originally triggered the need was taken of the planed product portfolio.
In the meantime a new product concept was in the final phase in Idea Land. The sensi-touch technology seemed relevant for this product.
Subsequently a number of additional models were developed to decide on the optimal configuration, and finally, the BeoCenter 2 was launched (see figure 11).

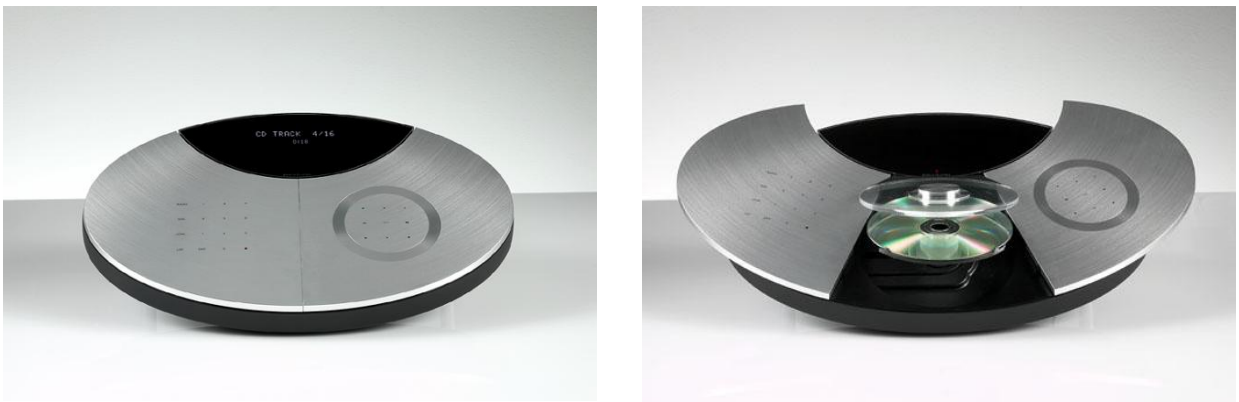

Figure 11 BeoCenter 2 with the sensi-touch user interface.

BeoCenter 2 is a combined CD/DVD player with integrated radio. The sensi-touch solution is an important part of the total design of the product. A light pressure with a finger will open the two wing formed doors and the volume is adjusted by circling the finger in the marked circular area in the right door.

The Bang & Olufsen reflections

The experiences gained on the sensi-touch case have let B&O to reconsider the importance and scope of working with prototypes. It has been acknowledged that prototypes have a broader scope than the pure technical originally applied.
As a consequence of this new insight the prototyping activities have been reorganized and a new department, “Prototypes and Innovation” has been established. It is the intention that the new department will collaborate closely with IdeaLand in the process of generating and testing new concepts.
One of the estimated effects is an increase in the launch rate of new products. The new department will be able to support a number of external designers and will eventually be a revolving part in keeping up the right quality and innovation level when engaging with more external people.

Conclusions and implications

Our present empirical material is limited – and too limited too support strong conclusions. However, based on this limited empirical material we can conclude that the view on prototyping has changed in the company reported. Since this company – Bang & Olufsen - has a major influence on methods for product development in Scandinavia it is realistic to expect a similar change in other companies. We will need to confirm this in future studies.

Until now, prototyping has mainly been developing technologically, but in the future it will be developed as a business tool. Like other business tools, it will have to justify itself on the basis of how much it can return to a company's bottom line relative to what it costs - just as would an engineering workstation, a new machine tool, a PDM system or an additional designer.

Most of these new viewpoints have to be further elaborated and developed. However, the case and recent experiences from Bang & Olufsen show that there are unexplored possibilities and that the effects from the re-orientation of the prototype work are promising.

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