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IMAGES OF INNOVATION - AN ONTOLOGICAL APPROACH

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1. Introduction

The aim of this paper is twofold: first, to discuss the diversity in research activities related to product innovation; second, to discuss the industrial implication of this research diversity.
From a research perspective innovation is generally perceived as the front-end activities to product development projects. However, since innovation research is a relatively young and unconsolidated field, these research studies tend to originate from different domains, and represent a wide spectrum of viewpoints. To have their research results published the individuals or groups need to narrow their focus which leads to a huge diversity and as yet no established protocols with which to facilitate comparison and accumulation of findings between research communities. This diversity results in the published findings of the studies being circulated and recognised mainly within their original domains, and points to the necessity of synthesising the knowledge that exists in innovation research communities to be useful for a wider community. From an industrial perspective the narrow focus and lack of comparison between research findings strongly contradicts the need to establish comprehensive understandings of the nature and control variables of the innovation process. The problem related to the innovation challenge of the industrial manager can be described as being a configuration problem with a high number of variables, having contradictory influence on the total performance. In general, industrial managers need a rich and transparent repertoire of views (images), so as not to be imprisoned by any particular one. This might explain the success of books such as Mintzberg et. al. *Strategy Safari* [Mintzberg et. al. 1998] and Gareth Morgan's *Images of Organizations* [Morgan 1986]. The latter has given inspiration to the title of this paper.

2. Motivation and methodology

Our methodology for constructing the ontology is inspired by the methodology for developing a product development process ontology, described by [Eris et. al. 1999], and consists of:

- Discussing the purpose and appropriateness of applying an ontological approach to product development projects
- Conducting literature review of bases, purposes, and methods of identification and classification in other sciences
- Formulating tentative ontological frameworks, conducting internal validations, and making the frameworks accessible to researchers, through the use of case studies
- Discussing the frameworks with colleagues from related fields such as engineering design, industrial engineering, civil engineering, mechanical engineering, and artificial intelligence.
- Developing criteria and evaluation systems for testing the validity, utility, and reliability of the proposed frameworks

In this paper we will discuss the first three steps.

3. A tentative classification framework for product development processes

Our empirical research activities within product development processes indicate that existing formal models of product development (e.g. Stage-Gate-Models) often provide an insufficient understanding and support of actual product development processes in industrial enterprises. Based on our empirical observations we propose three general classifications of product development processes: An *innovative* process, a *development* process, and a *customization* process, see figure 1:

- The innovative process is characterieed by a fuzzy process where the network activities are mainly informal and loosely coupled. Such processes can be initiated formally or informally as so-called skunk-activities. In each case the process can be either technology- or market-driven. Innovative processes result in a product concept with varying degrees of details.
- The development process is characterised by a structured process, where network activities can differ from loosely coupled to specified deliverables. Such processes are initiated by a decision to start a project. Development processes result in a set of detailed specifications.
- The customisation process is characterised by a focused and structured process, where network activities are mostly specified deliverables. Such processes are initiated by requests regarding the existing product programmes, i.e. project sales, OEM-customers, re-engineering projects. Customisation processes result in a set of renewed specifications.

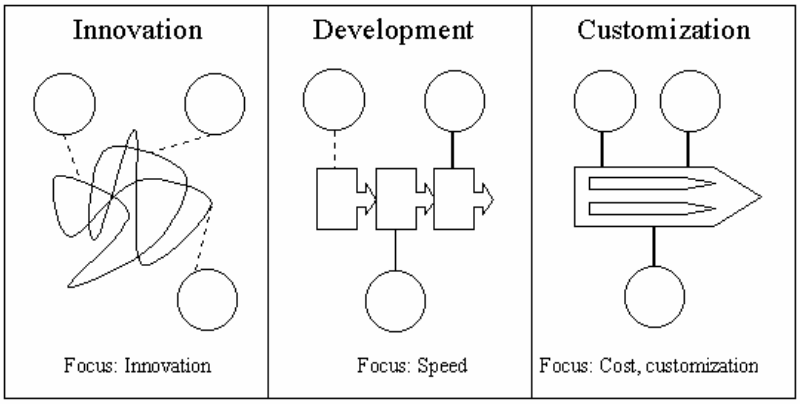

Figure 1. Classifications of product development processes

The characteristics of the three types of processes are so different that they can not be captured by one formal product development model. Ideally, a company has to have three distinct models to be applied when confronted with the particular types of product development projects. Also, these models have to operate with a number of different modes of network options.

The focus shifts in the three types of processes:

- In the *innovation type* of product development the focus will be on innovation, understood here as newness to the company and - if possible - newness to the market. This demand is indispensable and therefore speed, in the meaning of time-to-market, has lower priority. However, speed, in the meaning of timing, has to be considered as important as newness.
- In the *development type* of product development the focus will be on speed, in the sense of time-to-market. When the product and market features are determined it is important to get the product to the market as fast as possible. However, speed has to be balanced with quality and cost.
- In the *customisation type* of product development the focus will be on cost and options for customisation. Cost refers to both project cost and product cost. The important concepts are product and process platforms, modularisation, flexible manufacturing, etc.

The definition of the three types of product development processes opens for an important complementary discussion: the transition between the different types. We consider this question as being as important as the definition of the product development types. However, in this paper we will focus only on the *innovation type* of product development processes.

4. Innovation

The innovation process can best be described as circular process, similar to a learning process. Generically, the input is some kind of stimuli and the output is a product concept, hence, our understanding of the innovation process can be framed as illustrated in figure 2.

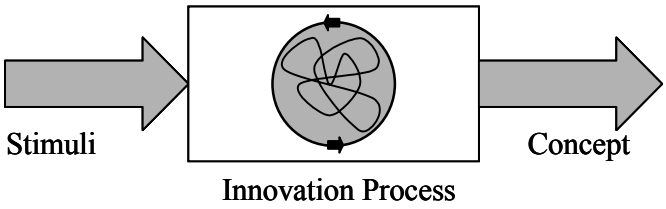

Figure 2. Framing the Innovation Process

With the increasing pressures of global competition, innovation is becoming increasingly important [Nijssen & Lieshout 1995] and NPD practices are becoming more sophisticated [Rothwell 1994]. The problem of conducting adequate analysis at the so-called fuzzy front end remains. Understanding the roots of fuzziness, and what problems this fuzziness causes as shown by Zhang and Doll [Zhang & Doll 2001] is helpful, but understanding front-end fuzziness may also be aided by a better understanding of innovation processes, which is characterised by a similar degree of solution-seeking under uncertainty. It is helpful to draw a distinction between "discontinuous" innovations, from which radically new product concepts may emerge, as opposed to the more common "continuous" innovation, which involves an incremental change in an existing product concept [Nijssen & Lieshout 1995]. Discontinuous innovation processes are described as being more exploratory and less customer-driven than continuous innovation, and it is argued that the formal front-end analysis recommended in established NPD models may not be feasible, perhaps even undesirable in discontinuous innovation processes [Nijssen & Lieshout 1995]. New working approaches characterized by *improvisation* are being recognised as having an important role in innovation, as well as cultivating values such as *trust* and *pride* in and within the development team [Rothwell 1994]. A common understanding of improvisation is that of having a great deal of freedom, but within certain constraints defined by a set of basic ground rules. This complies with the view that the opposing concepts of control and freedom are central in the management of innovation [Barclay et. al. 1994].
It is interesting for us to look at models of innovation, such as [Koen 2003] in an attempt to understand the early activities in the innovation process. The innovation activities circulate in a series of iterations until a convincing concept is derived, after which time the more step-wise and time-focused process of product devlopment can effectively ensure the development of the concept into a final, marketable product. It is our hypothesis that the successful execution of the front-end innovation process is key to the success of the product on the market; concepts that prematurely leave or entirely miss this stage of the innovation process run the risks of: unnecessarily disturbing the process of product development; and developing an unworthy concept to completion (thereby launching a low-yield product onto the market).

4.1 Images of innovation

In his book "*Images of Organization*", [Morgan 1986] presents a multi-perspecitve on the phenomenon of organisation, built on the notion that one cannot adequately understand complex organisations through a single perspective. The numerous types of people working in organisations operate based upon numerous different perspectives. Each view of the world creates its own understanding of the organisational problems, solutions and daily patterns of interaction. Building on metaphors, Morgan demonstrates ways of managing and designing organisations. An important quality of Morgan's work for us, is that it builds on a multi-disciplinary blend of theories, from philosophy through sociology, biology, anthropology and history.
Inspired by Morgan's inclusive approach to exploring a single phenomenon from a number of different viewpoints, a group of senior researchers, representing six Danish research institutions,

carried out an exercise, with the aim of collecting a series of "*images of innovation*". In this exercise each researcher attempted to describe their own image(s) of innovation, seen from their professional viewpoint. The researchers carrying out the exercise were part of a national research network which represented a number of different research backgrounds, from anthropology through sociology, product development, industrial design, engineering design, management and industrial manufacturing. The exercise resulted in 17 images of innovation, which gave insight into the neighbouring research field's frames of reference and understanding of the phenomenon *innovation*:

- Innovation as reputation building
- Innovation as a 'manageable' process
- Innovation as a stage-gate process
- Innovation as customer orientation
- Innovation as design for society
- Innovation as a staged process
- Innovation as a political process
- Innovation as a socio-technical process
- Innovation as a multi-disciplinary process
- Innovation as knowledge development and knowledge application
- Innovation as a process of collaborative learning and organisational reframing
- Innovation in established companies
- Innovation as an independent process
- Innovation as a process of business creation
- Innovation as a creative process
- Innovation as a rational problem solving process or as reflection-in-action (I)
- Innovation as a rational problem solving process or as reflection-in-action (II)

It was our hope that the images of innovation exercise would generate some visualisations of the various views on innovation. The exercise resulted in a series of discussions about each image of innovation, where a great deal of insight was gained about each "image owner's" view of innovation. Importantly, it was also experienced that each member of the research network had their own language, derived from their professional background. This gave confirmation of the need to work on an ontology, describing the meanings behind-, and relationships between attributes such as those found within the 17 images of innovation. Some of the important attributes covered in the 17 images of innovation include:

- Multidisciplinary teams
- Controlled process
- Value for the company
- Learning process
- Involvement of stakeholders
- Technology push
- Value for the society
- Innovation is limited by resources
- Market pull
- Chaotic activity
- Market understanding
- Modularisation
- User scenarios
- Organisational change

We believe that, by creating an ontological view of innovation (which should encompass the above and many other attributes connected to the act of innovating), we will be able to reach a higher level of understanding, language and thus insight into the management of the innovation process, applicable across multi-disciplinary platforms.

5. Building an ontology

Eris et. al. [Eris et. al. 1999, Mabogunje 2002] have, over recent years, begun to construct an ontology for the product development process. Their motivation for adopting an ontological approach is founded on the recognition of the problem, that especially empirical studies of the product development process often lack cumulative quality and transferability from one context to another. An ontology can be defined as the specification of a conceptualisation [Cross et. al. 1996]. That is, an ontology is a description (like the formal specification of a programme) of the objects, concepts, entities and relationships that can exist in some area of interest. A conceptualisation is an abstract, simplified representation of the area of interest. Its affordance is the consistent communication in a domain of discourse, without necessarily operating on a globally shared theory.

Table 1. Initial ontology for innovation in the context of a product development project

Dimension	Main Attributes	Sub Attributes/Thesauri
Actors	Skills, Knowledge, Roles, Motivation, Values, Emotions	adaptive, artistic, aspiring, changing roles, con/divergent thought processes, consensus, constructivism, coordinator, core capabilities, culture, dominant, experience, facilitator, formulating criteria, framing, fuzzy process, leadership, lifestyle, multi-discipline, multi-functionality, norms, owner, participating, personal identity, positivism, qualitative goal-setting, reliability, reputation, responsibility, tacit knowledge, venturing, vested interests
Activities	Cognitive	analysing context, analysing contingencies, assuming, calculating, competence building, competitive strength, constructing, converting, creating, customising, defining, design prototyping, drawing, empathy, establishing, experimenting, exploring, improving, improvising, interacting, interpreting, learning, linking, managing, optimising, problem solving, product modelling, quality managing, rational searching, reflecting, renewing, restructuring, satisfying, searching, servicing, setting the stage, sketching, stakeholder consideration, structuring, systematising, testing, user understanding, venturing, visioning, visualising
	Social	collaborating, collegial sparring, communicating, conversing, customer orientation, drama, meeting, networking, organisational reframing, participating, playacting, political group working, recruiting, socialising, storytelling
	Physical	
Information	Representation	
	Level of detail	
	Level of abstraction	abstract, concrete
	Source	externally, internally
	Interpretation (context)	decision making, exploitability, norms, reflection, solution space, trade-off, uncertainty,
Organisation	Organisational Structure	coalitions, company growth, corporate identity, decentralising, disruptive technological shift, gamerules, informal relationship, market domination, market exploitation, multi-disciplinarity, multi-functionality, organisational change, organisational development, skunk-activities, strategic architecture, strategy, supportive technological shift, technology, technology driven
	Physical Distribution	
	Physical layout	occasions, spaces, working environment
	Methods/approaches	creative destruction, creative overlap, creativity, design games, designing the design process, designing-in-context, interaction design, interactive prototypes, mental visualisation techniques, multi-product development, portfolio management, product characteristics, reflection-in-action, stakeholder forums, systematic methods, technological integration, user groups, user participation, visualisation exercises

In this paper we further develop the ontology by firstly remodelling the main dimensions, to account for lessons learned in three previous developments of the ontology. Secondly we have loosened the structure of the main attributes in relation to previous versions of the ontology, in order to allow for the circular, iterative nature of innovation process to be represented optimally. Finally we have

manually reviewed the 17 images of innovation and the literature referred to in this paper, in order to build and classify the sub-attributes of the ontology. These sub-attributes, in turn, inform the main attributes and thus the overall structure of the ontology.
The dimensions and the structuring of the main attributes listed in the figure are adapted from previous papers in this series. The sub-attributes in the figure represent the data-set for this study, namely the 17 images of innovation. It is particularly interesting to note that the data-set in this empirical study gives rise to an expansion of the 'organisation' dimension, compared with earlier product development-oriented versions of the ontology, and does not at all describe the physical artefact itself. We can reflect that the focus on the very early and fuzzy front end of innovation gives rise to a host of considerations about both the company's organisational structure and the approaches adopted to ensure targetworthiness in this phase.

6. Case

The specific perception and visualisation of "Innovation" inside a company is crucial to establish a deliberate innovation process that can be inspired and developed by theoretical findings and experinces from relevant practical settings. This case describes an attempt to make such a visualisation by means of a LEGO product. The product is called *LEGO Serious Play* and consists of a physical product of carefully selected LEGO bricks. As an example of a LEGO Serious Play session, workshop participants build models of their perception of the current state and challenges of their company [LEGO Serious Play, 2003].
When all board members have built their models (this may be ten-minute sessions) the members take turns to explain their models to their colleagues. Colleagues will typically engage deeply in the stories and will ask questions such as, "why did you pick a transparent brick to symbolise our marketing campaigns?" This all ensures a much more engaged and lively discussion of the topic at hand.
One workshop participant, his model shown in figure 3, explains: "I learn from others, I need stability, so I can look in all directions, my brain is red hot with ideas".

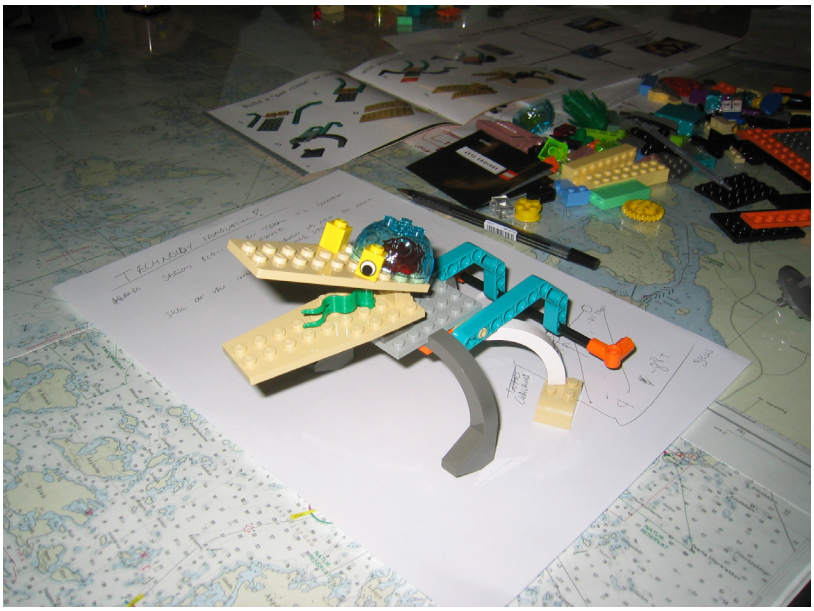

Figure 3. An Image of Innovation

Another participant explains: "I am an innovation animal that scouts for and eats up opportunities and then spits them out in workshops and brainstorms with my colleagues" (figure not shown). Finally, a product manager comments: "Innovation is an uphill battle, but can be fun. There are hindrances on the way, but they can be overcome when we pull together. All assumptions and prejudgments must be put away as illustrated by the blue ball hidden under the model. You will find yourself on shaky

ground now, especially when you are close to reaching the goal. This is illustrated with an elastic band as the last part of the ramp leading to the ultimate goal" (figure not shown).
While the LEGO Serious Play exercise does facilitate the expression of how the participants percieve the present innovation state of their company, the participants generally experience difficulties when entering into a discussion of how to configure the innovation system. Hence the practical need for the ontology.

7. Discussion and implications

We feel comfortable with the dimensions that we have presented in this ontology; these have been developed over a series of empirical studies, based upon product development projects and it is interesting to see how the dimensions further develop in order to be able to encompass the observations made whilst building our initial ontology of innovation.
In this paper we have only partially related the main attributes and the sub-attributes/thesauri to each other. A further relation of these two sets of attributes will give a richer definition and thus understanding of the make-up of the innovation activity, thereby facilitiating the configuration of the innovation system.
If the sub-attributes/thesauri were to be further refined and classified, it would be possible to initiate an empirical process of relating groups of sub-attributes to specific research groups and research interests. This, in turn, would ensure a multi-disciplinary approach to empirically describing the sub-attributes and provide a deep level of richness to the ontology.
The case we have shown exemplifies typical sub-attributes (in our ontology language) that can arise in an innovation process. The three examples briefly presented in the case represent different participants' images of innovation, expressed and displayed in a way that can easily communicated to others. It is our belief that the ontology could be useful in this case, both in the process of broadening the innovation's scope and of understading the particpant's intentions when dealing with the configuration challenge that the industrial manager is faced with.

8. Conclusions

In this paper we have taken the first steps in describing an ontology for innovation. We believe that this emerging ontology will be useful for both industry, in the planning of the innovation process and for the classification and association of research contributions. The data-set we had access to for this study represented the works of a broad, multi-disciplinary group of senior researchers from Denmark, giving a good starting base for the ontology. However, we are aware of the need to begin to enrich the ontology with a series of deep empirical studies, and therefore encourage our peers to critically devlop the ontology further.

Acknowledgement

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LEGO Serious Play, please visit http://www.seriousplay.com for more information.

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