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The Microinnovation Approach in Design

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Abstract

Engineering design is here understood as a multi-phased thinking and problem solving process which creates new information and constructs. This perspective is referred to by us as the microinnovation approach. It forms the basis of this study, the aim of which is to analyze design errors and to identify thought errors behind them. We have interviewed professional engineering designers to search for the reasons for design errors. We found evidence of some such reasons including: 1) problems in organizational coordination, 2) haste 3) communication failures, 4) unavailability of and lack of access to knowledge, and 5) problems in professionalism. The main thought errors behind these problems were lack of long-term thinking and narrowness of perspective. By eliminating these problems and shortcomings, organizations could decrease the number of risk factors for design errors and hence increase innovative thinking.

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The Determinants of Innovative thinking in desing - Microinnovation approach

Abstract. Engineering design is here understood as a multi-phased thinking and problem solving process which creates new information and constructs. This perspective is referred to by us as the microinnovation approach. It forms the basis of this study, the aim of which is to analyze design errors and to identify thought errors behind them. We have interviewed professional engineering designers to search for the reasons for design errors. We found evidence of some such reasons including: 1) problems in organizational coordination, 2) haste 3) communication failures, 4) unavailability of and lack of access to knowledge, and 5) problems in professionalism. The main thought errors behind these problems were lack of long-term thinking and narrowness of perspective. By eliminating these problems and shortcomings, organizations could decrease the number of risk factors for design errors and hence increase innovative thinking.

I. Introduction

Innovations are crucial for modern economy. They bring about much of the growth in economy and thus also much of our well-being. We are quick to consider them as large scale phenomena only. As Dogson (2000) points out, innovation is mostly thought about in policy or management terms. However, the ground of all innovations is always human thinking. This view, which we call the microinnovation approach, is the core assumption here (Saariluoma & Kannisto 2008; Saariluoma, Kannisto & Kujala 2006). In this paper, we study what kinds of thought-related obstacles to innovations could be found in design work.

There are numerous thought-related phenomena, which can explain different aspects of innovation. One interesting perspective is to investigate the obstacles hampering innovative thinking. Here, the interest is placed on mistakes people make in their innovative thinking. These mistakes appear especially clear in design. Therefore, we have studied engineering design thinking and errors in it to see how ground level innovation processes may be impeded by human errors.

Design is at the core of microinnovation process, because design thinking creates new ideas and constructs. When designing, individual designers start thinking in a new way and pursue new goals. Shortly, design is essentially about thinking (Simon 1969). Thinking is a process, which emerges when people do not have direct means to reach their goals (Newell & Simon 1972). Thinking leads to new means to reach certain goals, and thus improves our capacity to adapt to the conditions set by nature. However, thinking does not always lead to good solutions and practically never to optimal ones. If the outcome of a design process is not what was expected or hoped for, a thought-error has taken place. Thought errors thus make the design worse than it could be.

Consequently, we decided to ask design engineers to describe us those circumstances in where design errors have taken place. In this way, we could collect information about various types of factors, which can explain why design processes are risky and why they can fail. By analysing errors, it is possible to recognize risks situations.

II. Methodology

We interviewed professional designers from small and medium-size firms to search for the reasons for design errors. Twenty active designers were interviewed. Contacts to them were made with the aid of SKOL (The Finnish Association of Consulting Firms). The participants were mainly technical designers in the fields of HVAC-design (2 designers), electrical design (3), lift-design (1), structural engineering (4), geotechnical engineering (1), biotechnology (1), metal engineering (1), strategic planning (1), tunnel engineering (2), road planning (1), macine design (1), and architectural design (2). The goal of the interviews was to get the subjects to describe one of the most memorable design errors in their work life. This theme was completed with questions concerning their organization, co-operation and communication, scheduling and tools. In this way, we obtained a multifaceted picture of thought errors and risks in design work. The interviews were tape-recorded, transcribed, and analyzed qualitatively in order to extract different types of explanatory factors.

III. Results and discussion

The results were qualitatively analysed. First, we extracted five main types of reasons to errors in design: A) problems in organizational coordination, B) haste, C) communication failures, D) unavailability of and lack of access to knowledge, E) problems in professionalism. Second, we investigated the subtypes of each major category. Finally, we investigated what kinds of thought-related problems could be found in each of the five categories.

A. Problems in organizational coordination

Well-defined goals are largely acknowledged as important prerequisite of innovations (see e.g. Nonaka and Takeuchi 1995). However, *unclear goals* were mentioned to be one of the major problems in design work. Unclear goals form the first subtype here. The huge amount of people involved in a design process and lack of co-ordination were the main reason for this kind of problem. Goals were set in many different levels (e.g. finance, architectural) and co-ordination between these levels were often poor. Also the interaction and dependence between different levels was not taken into account enough. The holistic view was missing and no-one was aware of how changes in some area effect on the other areas of a design process. When considering these kinds of problems from a light of thinking, we found evidence on reliance on numbers of actors. When there are many people involved in a process, it is easy to shift responsible to others. Instead of decentralized management, management was often vague: no one was actually in charge because of shifting responsibility. Sometimes goals were unclear simply because they were not properly set in the first place. This kind of error was most often due to tight schedules: designers were forced to start design even when project plans were unfinished. A planning stage and an actual design stage were no longer sequential but overlapping. One interesting type of thought error found here is called illusion of control, by which we mean falsely assuming that everything is under control and that everybody knows what to do. Illusion of control may derive from past experiences: if everything went well in last

project, it will go well again, despite the fact that the present project and the people in it may be totally different.

The second subtype is *lack of goal-oriented action.* Concentrating only on present time and lacking long-term thinking are the thought errors behind this subtype. Innovation activity is often considered to be based on free-floating and arbitrary actions. However, although creating new products and concepts demands creativity and changes in thinking patterns, innovation process is not an uncontrolled chaos but rather an organized path to problem solving (Sandberg 2005). One part of the organized path of problem solving is formed by target-oriented actions. Goal-oriented actions have been found to unleash the energy required for experimentation, without which no innovation will emerge (Leifer 1989; Nonaka & Takeuchi 1995).

The third subtype, *variability of internal goals*, makes project work difficult. When the goals are not common goals, it is hard to reach a consensus. Illusion of control and narrowness of perspective were found to be the thought errors here. Narrowness of perspective refers to inability to see others' viewpoints. This can lead one to the point where a holistic view on projects is not achieved:

"The management emphasizes economical aspects of designing; designers, on the other hand, focus on functionality and creativity."

The fourth subtype concerns goals, namely *too rigid goals.* If sudden changes are not taken into account in project plans, problems can occur. There can be changes in project finance or project timetable and they may affect the goals. To avoid thought errors, the goals must be adapted to current circumstances. Thought errors here are related to lack of long-term thinking and inability to detect changes in circumstances. Capacity to react to changes is usually better in organizations with a low hierarchy and bureaucracy. These types of organizations are also considered to be more innovative than organizations with less flexible practices (Aiken & Hage 1971; Burns & Stalker 1961; Damanpour 1991)

"Contracts are often too strictly scheduled beforehand, and therefore all possible changes along the project cause problems. For example, the amount of work can suddenly increase, but it is not supposed to have effect on schedules."

Complex and simultaneous projects form the fifth subtype. This problem makes design risky. Complexity refers to situations with a huge number of people involved in some projects and to the difficulties to locate people in charge of these projects. Also a holistic view is often missing due to complexity. Organizations' complexity can also lead to communication breakdowns if information doesn't reach everybody. Problems like these are, to some degree, inevitable because of the nature of design work: it is financially impossible to concentrate only on one project at the time. But some thought errors could be found in data, namely those related to illusion of control and overestimation of human cognitive capacity.

" Everything is a big mess… According to the construction law, the person who should be leading the project, the chief designer, is responsible for construction. But chief designers don't always understand that they are supposed to be leaders. And a product

consultant, who is expected to know everything, may know nothing. And then he or she asks around what is going on…"

The sixth subtype, *insufficient finance and insufficient personnel resources*, was also a typical organizational problem faced by designers. It is problematic to balance the number of personnel with the actual needs because the number of design projects in organizations varies a lot: sometimes there are several simultaneous projects; sometimes there are only a few. Like the complexity and simultaneity of the projects, insufficient resources are also due to the nature of design work. It is hard to predict future activity, and it is financially impossible to be fully prepared. However, the ability to detect changes in circumstances was often found to be poor.

"There are no extra people in this field. There is no one you can turn to when things are getting too busy and you could use some extra help. Lack of employees is a common concern: when you are busy, everyone else is busy too."

Organizations' resources have great impact on design activities. In general, the more organizations have available or slack resources, the more capable they usually are to develop new products and procedures (see e.g. Damanpour 1987; Rosner 1968; Rogers & Agarwala-Rogers 1976) Slack resources allow an organization to afford to purchase innovations, absorb failure, bear the costs of instituting innovations, and explore new ideas in advance of an actual need (Rosner 1968). A number of researchers have suggested that resource allocation to projects is directly related to the projects' creativity levels (Cohen & Levithal 1990; Damanpour 1991; Delbecq & Mills 1985; Farr & Ford 1990; Kanter 1983; Payne 1990; Tushman & Nelson 1990).The adequacy of resource may also affect people psychologically. The intrinsic value of a project is automatically considered to be low if resources are extremely limited (Amabile, Conti, Coon, Lazenby & Herron 1996)

B. Haste

The situations mentioned above, as insufficient resources and simultaneous projects, lead easily to another problematic situation, which is due to haste. Designers have too many things to do. In many cases haste was caused by *tight schedules*. Thought errors here were found to be related to the incapability to see the whole picture and lack of long-term thinking. These kinds of thought errors could be traced to the management level. Tight schedules were often caused by the managements' willingness to decrease design time in order to cut down costs. Haste also decreases the quality of design. Errors become more common when there is no time for quality assurance.

"It takes a lot of time to do design work, but there is no time for it. People use ten hours for the actual design and 550 hours to correct design errors."

The second subtype is called *dependency on other parties* involved in the project. If there is a delay in some point of the project design, it will affect all. No long-term thinking, no backups, and the narrowness of perspective were found to be thought errors here.

The third subtype concerns *the process and seasonal nature of design work*; at some point of time a project demands a lot of work and at some other time there is much less work. These kinds of problems are due to thought errors in management level. Lack of long-term thinking, concentrating only on present time and narrowness of perspective are thought errors found to explain these kinds of problems.

C. Communication failures

Communication is an essential part of design. Respondents most often mentioned communication problems occurring between customers and designers. These problems can be explained by the first subtype, *lack of mutual language*. The narrowness of perspective and insensibility/incapability to adapt behaviour to situations were found to be major thought errors here.

The second subtype is called *customers' unawareness of the realities related to design work.* Here too, the thought errors are originated from the narrowness of perspective, but also from feelings-over-sense thinking. This kind of thinking occurred particularly in situations where experience and professionalism were poorly respected by customers.

The third subtype emerges when customers and designers have *different expectations:*

"Customers and designers have different viewpoints and goals, and achieving mutual understanding is hard."

There can also be difficulties between designers and such professional parties as sales people and constructors. Incapability to see the whole picture and narrowness of perspective were the thought errors found here. Also, the huge amount of different parties involved in projects caused communication problems. Illusion of control and overestimation of capacity were the main thought errors in these kinds of situations.

D. Unavailability of and lack of access to knowledge

Poor access to knowledge caused problems. Relevant knowledge was not always available due to *information breakdowns,* which forms the first subtype here. Illusion of control is apparent here – the false assumption that knowledge is reaching everybody even when it is not.

The second subtype is *poor documentation*. Concentrating only on present time and lack of long-term thinking are the thought errors here. In some cases also narrowness of perspective can cause these kinds of problems: documentation is simply ignored because its relevance may seem low.

The third subtype, *limited access to knowledge,* was also mentioned as causing problems in some cases. This kind of problem was found to be related to thought errors such as losing-when-sharing and overprotection. Knowledge was not shared because it was thought to negatively affect one's own standing. But in reality, not sharing was creating problem in most cases.

The fourth subtype concerns *difficulties in finding relevant and reliable knowledge*. There may be too much knowledge available, and it is therefore difficult to spot the right information. Illusion of control and overestimation of capacity are the main thought errors here.

The fifth subtype, *raw and unfinished knowledge*, is closely related to the previous subtype. Relevance was often found to be dependent on the quality of knowledge. The quality was often found to be low; it was too easy to spread knowledge, even when that knowledge was incomplete. Also allocation of knowledge was not as good as was hoped for. These kinds of problems can be explained mainly by quantity-over-quality thinking.

"Nowadays it is too easy to spread information: you just send email to everyone without thinking whether it is relevant or not to receivers. And it takes time to sort out all the relevant and less relevant messages."

Also incorrect knowledge forms its knowledge. Incorrect knowledge could have been easily avoided by double-checking.

Organizational activity is based on communication. Creation, storing, distribution and application of knowledge becomes possible through communication (see Forcadell & Guadamillas 2002.) Communication channels constitute a network where knowledge is combined and accumulated into a new knowledge and new solutions. The relation between communication and innovation has been studied extensively. According to Länsisalmi, Kivimäki and Elovainio (2004), problems in communication within an organization, its partners and clients, or between them, weaken the organization's ability to innovate. (see King, Andersen & West 1991; Kivimäki, Kuk, Länsisalmi, Elovainio; Thomson, Kalliomäki-Levanto & Heikkilä 1997; Forrester 2000; Kivimäki, Länsisalmi, Elovainio, Heikkilä, Linström, Harisalo, Sipilä, Puolimatka 2000).

E. Problems in professionalism

The first subtype here is called *low status of design work.* This study proved that designers did feel low about their status. Design work may not involve such public glamour as many other professions. Therefore, designers may be disposed towards underestimating their significance in society. This underestimation is clearly a thought error, based on a biased view about oneself. The low status of the design profession was considered in some cases to influence design education as well: young people are not eager to study design.

"There is a lack of young designers. Young people chose the IT-field over design."

The second subtype is *lack of experienced designers*. Some designers also saw problems in schooling. They felt that newcomers had deficiencies in their design skills. Problems were partly caused by the nature of design work: design is not something you learn at school; becoming a designer requires experience of real work life. Beside the problems related to the nature of design work, some thought errors were found too: concentrating only on present time and lack of long-term thinking. Some respondents thought that quality requirements were lower than before.

"There are not enough skilful people in this field. At the moment we have lot of work but it's hard to find experienced people."

"Design requires persistence; it takes time to reach the level where you really understand what design is about."

The third subtype, *competition*, is a part of professional identity of designers today. However, according to the designers, competition has reached its limits, which has lead to the following problems: the design standard has been lowered, and the prizes no longer correspond to the work. As can be seen, competition is limiting the demand for designers as they must, at all times, look for solutions with minimal costs. Often good solutions, from clients' point of view, must be rejected because of the costs involved. The quantity-over-quality thinking is obvious here.

Previous findings on the relationship between professional expertise and innovation have been mixed (see e.g. Damanpour 1991; Forrester 2000). The concept of routine is one of the complex issues related to expertise and innovation. Routine is knowledge achieved through experience and is based on tacit knowledge (see e.g. Unsworth 2004). Routines emerge when the circumstances remain unchanged and stable. Routines are often said to kill innovativeness, but, on the other hand, routines increase thinking capacity, as attention can be focused on things other than routine actions. Experienced designers know on what to concentrate and are able to ignore irrelevant cues. In fact, several studies have illustrated a positive relationship between routines and innovativeness. (see e.g. Feldman & Pentland 2003; Feldman 2000).
Job satisfaction is also a key determinant in innovation activity. Pierce and Delbecq (1997) have showed that job satisfaction is positively related to innovations. People experiencing high work satisfaction are more committed to their work and more willing to improve their performances. They are also more open to new ideas (Pierce & Delbecq 1977).
Psychological aspects are also related to innovation ability. Perceiving oneself as successful and recognized could have a positive effect on innovation activity (Cyert & March 1963).

General discussion

Human thinking does not take place in a vacuum: it has numerous preconditions. In organizations, circumstances which make thinking difficult very often emerge. Here we have found a number of factors which impair smooth thought processes in design.
In analysing such microinnovation processes in design, we have to consider various external conditions for good thinking. Factors which influence human thinking and which can explain some related problems were categorized as following: own special case. Haste was mentioned as the main reason for incorrect problems in organizational coordination, haste, communication failures, unavailability of relevant knowledge, and professional identity issues.
These factors are closely linked to each other. Organizational problems lead to haste, poor communication and lack of knowledge. Often these problems could be solved by organizational means. However, to do that, we should understand how communication and haste, for example, affect thinking.

Haste is a complicated issue in design thinking. It easily leads thoughts to routine and uncreative paths. In design, this phenomenon is problematic in two ways at least. Firstly, haste prevents creation of new ideas, as designers do not have time to search other than routine solutions to their problems, and, secondly, when it is necessary to solve problems in new ways, there is a risk that something has not been taken into account. Consequently, there is a risk of design errors. According to Saariluoma (2003) one of the most crucial risk factor in creative thinking process is indeed haste. Haste can lead, besides routine-based thinking, to negligence in details. Hards (1999) found that tight timescales and deadlines caused design engineers to be satisfied with less creative options than they would have been, had there been more time available. Some studies suggest that time pressure actually increases innovation. Time pressure challenges and motivates people to work harder. (see e.g. Bunce & West 1994) However, this suggestion was not confirmed in our study. According to Amabile, Hadley and Kramer (2002) time pressure could have both positive and negative effects, depending upon certain environmental contingencies. Amabile, Hadley and Kramer (2002) illustrated that under high time pressure, creative thinking was more likely when people felt they could work undisturbed and when they felt they were doing challenging, important work. Creative thinking was less likely to occur under high time pressure when people felt distracted, when they did not feel the work was important, when they worked in groups rather than alone or in pairs, and when they experienced lots of last minute changes (Amabile, Hadley and Kramer 2002). In our study it was obvious, that haste was experienced nothing but hazardous to thought processes in design. Also the study of Unsworth (2004) showed that time pressure is a contextual factor. That study consists of interviews of 65 engineers, the majority of whom were design engineers. The results proved that there were three main mechanisms through which time pressure affected employee innovation: increasing prioritising, narrowing the focus of work, and increasing risk aversion. Time pressure meant that tasks were prioritized and only high priority tasks were performed. Innovation, and particularly innovation that wasn't task related, was of a low priority for participants (Unsworth 2004).

Since modern design is team work, communication forms an essential part of it. The problem is often in the relevance of communication. People easily send messages which are not needed. This wastes other people's time. It is also often the case that the messages do not go to the right people, and consequently their capacity to solve problems decreases. No wonder that many of the interviewed called attention to the lack of relevant knowledge. Of course, parts of these problems are related to knowledge management and information systems: people do not get the knowledge they really need. Finally, it may also be that no relevant information exists.

The final set of reasons to thought errors in design can be classified as problems in professionalism. This refers to a large set of problems that are mostly linked with experience and skills, and thus may indicate that designers are sometimes professionally inexperienced. Lack of young designers is also a problem. This leads to shallow organizations. Because design is cognitively demanding, it requires intensive efforts. In this, experience is often an important advantage.

Considering a modern design organization, the factors presented can be seen as organizational risks. It would be rational to eliminate them by organizational means and in this way provide designers with better conditions for their creative work.

Our analysis has illustrated one aspect in microinnovation processes. Human thinking is part of the system considered, and this system must ensure it the best conditions for success. Obviously, thought errors are not directly linked with any particular person but rather to various factors and preconditions. These preconditions can often be tackled by organizational means. Indeed, finding such means and getting optimal conditions for design thinking is one important goal for microinnovation research.

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