INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN
ICED 03 STOCKHOLM, AUGUST 19-21, 2003

INNOVATION THROUGH EXPLORATIVE THINKING IN PRODUCT DEVELOPMENT PROJECTS

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Abstract

Product development projects, specifically within software development, face a situation often characterized by shrinking margins, short product life cycles and continuous introduction of new technology. Much effort is put on finding ways to work faster and cheaper which results in that software projects primarily support short-term problem solving and offer quite limited opportunities to question and reflect on present solutions and practice. It is necessary to find ways how to make product development projects contributing to renewal and innovation of products, solutions and working practice.

The purpose of this paper is to explore the ability to enhance creativity in general among the broad number of project participants. The result, based on studies performed between 2000 and 2001, shows a number of issues worth considering to reach higher levels of innovation. Access to first hand information and key people made it easier to question and debate tasks and the formulation of problems. The product in itself had a great impact on individual motivation depending on the possibility to visualize and to see the benefits from using the product. Another strong motivational factor and driving force was provided by the interaction with the customer.

Keywords: Human creativity, innovative products, drivers of innovation, project management, product development

1. Background and purpose

Companies responsible for developing, producing and selling products and services are forced to constantly improve or find new offers, attractive to the market. One of the strongest driving forces, on a company or industry level, is to follow the evolving customer requirements or expectations. A customer orientation differs quite substantially from a more technology-oriented approach when developing new products. The chance of reaching innovative height in products is much higher if the opportunities of new technology are explored compared with the customer's view on new product ideas [1]. There is on the other hand not necessary nor desirable to have an either or strategy but companies seem to have a tendency to fall into a single mode of operation, exploring technology or chasing customer needs. The trick is to stimulate explorative thinking in as many parts of the organisation as possible.

Product development projects face a situation often characterized by tight deadlines and shrinking margins which drives initiatives on how to work faster and cheaper. This is especially true in software development projects where product life cycles in addition are extremely short and new technology continuously introduced. Empirical research shows that software projects often end up supporting short-term problem solving and quite limited

opportunities to question and reflect on present solutions and practices [2]. Keeping up with the development of new technology and emerging customer needs is a well-known problem within R&D functions. Designers tell about the loyalty toward project deadlines instead of prioritising the exploration of new technology or untraditional solutions when time and delivery plans are tight.

The problem facing companies and employees in a situation like this is that the pace of innovation is simply not high enough. It is necessary to find ways how to make development projects contributing to renewal and innovation of products, solutions and working practice. There is no longer time enough to let separate departments be responsible for all innovative thinking, the situation truly requires cross-functional and departmental co-operation and interaction.

In this paper we will show that the present practice within the investigated software development projects to a limited extent support explorative thinking that could lead to more innovative solutions to problems or more innovative products. The purpose of this paper is to explore the ability to enhance creativity in general among the broad number of project participants.

2. Innovation and creativity

Innovation is not a straight forward, easy to define concept and therefore it is of importance to state how innovation is to be understood in this paper. By innovation is usually meant the actual outcome of a design activity or product development process. It could be a whole system or product as well as a subsystem and offer a range of uniqueness to the market, everything from a radical to incremental innovation. Innovation could also be a process, meaning a company's total ability to offer attractive products to the market. On this strategic level one important aspect is to combine the company's internal product development capabilities with an active dialogue with the development of the market and technology, see e.g. Allen [3].

The interest in this paper lies in the observed behaviour and issues close to the individual designer that could support innovation. The way we chose to study this is to search for situations or structures that create or support innovative or explorative thinking. Questions of interest are how to avoid a routine fashion use of already known and proved solutions and strategies in problem solving. One of the key human process and prerequisites for explorative thinking for innovation (as defined in this paper) to happen is the existence of creativity. A definition offered by Mckenna [4] views creativity as a human process, including the escape from pre-assumptions and the discovery of new and meaningful perspectives.

One important question that heavily influences how to relate to the theories and practice of creativity is whether to regard it as a universal process found within everyone or not. Within literature both directions could be found, Amabile [5] shows different perspectives where one makes a clear distinction between the output from geniuses and ordinary people. It is the work and output of people with certain personality, skills and information processing abilities that should be regarded as creative. Our opinion is that this way of looking at creativity and people would be to disregard a lot of human potential.

Creativity and projects

Ekvall [6] shows that one of the main considerations within development projects is the balance between freedom and control. Rigorous control is positive to secure keeping costs, goals or customer needs but negative for creativity. Certain levels of freedom in projects could lead to totally new ideas on the whole problem area or the portfolio of possible

solutions to problems [7] in [6]. The importance of maintaining high levels and opportunities for creative thinking does not exclude the fact that different phases of product development, different products and organizations require different levels of creativity [6]. Early phases of the product development process clearly must have room for creative and open thinking but it must be possible to quickly open up for creative thoughts and innovative problem solving in other phases as well.

Product development is most commonly organised and run in projects. Some of the strong assets of project management are the clear focus on planning, structure and control as a way to fulfill the project goals. There are few doubts that projects could provide a beneficial environment for structured and efficient work. What can be questioned is how purposeful the present practice of projects are as an environment for increased levels of innovation. The dominating perspective of project management has been to find ways to optimise methods and to identify success factors [8]. With this more rationalistic way of looking at work in product development there is very little space for exploration of more uncertain ideas. One reason that project management is so influential and appreciated among managers is the risk reduction that it provides, another aspect contradictory to innovation.

Creativity and product development

Amabile [5] present three major components of creativity. These components point out that there is no coincidence in repeatedly reaching innovative products or solutions. There is a need to have factual and technical knowledge as well as some special talent to work as e.g. an engineer within product development of a certain product, *domain relevant skills*. Creativity further requires a specific working style and way of cognitive thinking, *creativity domain skills*. Finally the team or individual have to be motivated for the task and to search for new solutions, where intrinsic motivation seem to have the strongest impact, *task motivation*. This is motivation that "…arises from positive reactions to the task itself in the form of interest, involvement, curiosity, satisfaction or positive challenge" (ibid).

What Amabile [5] further introduces is the role of the *social environment* on primarily the task motivation. The environment includes both structural as well as interpersonal aspects of the everyday work. Other authors mention similar concepts or factors influencing creativity and motivation. Mckenna [4] point out supporting norms and values for creativity whereas Ekvall [6] use the measurement of specific indicators of a creative climate. The indicators measured are e.g. the levels of challenge, freedom, idea-support, trust, debates, risk taking and idea-time.

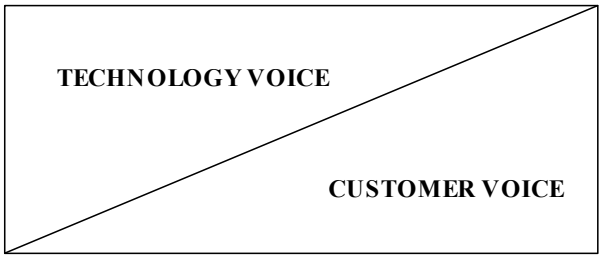
Product development literature provides a connected picture of how to organise product development but from a company perspective. The critical factors to manage for dealing with new tasks and innovation are leadership, the individual, the informal organisation and the formal organisational arrangements [9]. The individual includes the skills and expertise of the employees or designers. The informal organisation is the norms, values, communication and behaviour that can be observed but not controlled. Finally the organising arrangements are the organisational structures, reward systems, training etc. that are in place to support innovation.

The requisites in the short-term perspective for product development are to be efficient but maintain high quality. In the long-term perspective it is a matter of both acquiring information and opportunities from the external environment as well as processing that information and transforming it into action [9].

Innovation and customer interaction

Regardless of the time perspective the importance of having a clear view of the customer requirements is emphasised by several authors, e.g. Cooper [10]. Depending on how single

focused a company is to follow the voice of the customer it gets different consequences of the kind of innovation that could be expected.



Breakthrough
New Products
- Visioning the Market
- Building and creating demand for the product

Incremental
New Products
- Listening to the Market
- Effectively and efficiently addressing existing demand

Figure 1. Two models of market learning [1]

As can be seen breakthrough new products require a greater input from technology than market input. In a situation of radical innovation the role of the market or customer input is more of enhancing proactive behaviour than collecting concrete customer requirements [11]. Utterback [12] warns about being blindly addicted to the voice of the customer if there's a need for radical innovation.

Product development models or processes often end up in stating how to work efficiently to secure that customer needs, specifications and time limits are met. New product development processes and models are generally described in a similar way [13], e.g. as an eight-stage linear model including steps from idea generation to commercialisation. In Wheelwright and Clark [14] for example you can find both what the process of product development should look like and how to set-up a project-based organisation for execution. There is a risk that these more prescriptive models become the perception of how to run product development. This would be far from the complexity of the challenges involved to achieve innovative products.

3. Methods and participants

This paper is based on the results from studies involving development projects within two Swedish companies, Ericsson Radio and Sectra Imtec. These original studies investigated the practice of product development in issues like the application of project and product models, learning and knowledge, leadership, customer interaction and the organizing of innovation. These studies can be found with more details in Sundström [2] which discusses the role of development projects in innovation.

For the purpose of this paper the studies have been used to show how innovative thinking was supported and hindered within the two organizations. The aim has been to push the discussion one step further and re-analyze the empirical material from the original studies with the help of another theoretical tool.

Data was collected during the years 2000 and 2001 using a survey, interviews and participatory observation. The survey at Ericsson involved two software development departments with 72 respondents complemented with personal working experience from the company. The occupational categories represented were primarily designers, testers, project

managers and team leaders. The typical, average, employee was a male engineer with a BSc or MSc in computer science from a technical university with a working experience of 15 years.

The interviews at Sectra were primarily performed within a software development project and included all participants and selected managers, in total 11 persons. Interviewees represented designers as well project managers. Another important source of data were the participation within the project as a configuration manager during three months.

3.1 The software development projects at Ericsson Radio

The two departments within Ericsson Radio had the responsibility of radio base station development for mobile telephony, both GSM and the new standard UMTS. The running projects were both part of a complex international project structure divided into one organization for GSM and one for the new generation of technology UMTS. Several versions were developed simultaneously with content and functionality controlled and ordered from a central product and project management function, at another geographical site.

The departments consisted of in total 160 people, primarily SW designers, with two department managers and four section managers. The department's staff was assigned to different projects in agreement and discussion between managers and project managers. The different projects consisted of teams of about 4-6 designers and testers with a team leader. Depending on the competence people possessed and the resource needs it was common for project participants to share their time between several projects.

The departments were at the time facing a heavy expansion to more or less twice the number of employees. Two other challenges were the switch to a new way of working and the transition into a new technology, 3G and UMTS, and signs of stress could be noticed. The project model used was the commonly used PROPS model, basically in line with the philosophy of e.g. Cooper [10]. The way of developing software was strongly influenced by the incremental development philosophy, pushing for high levels of parallel work. Due to the complexity and size of the system development projects work was characterized by a high reliance and need of written requirement specifications and project documentation. Followed by the size and number of people involved much effort and focus was put on the planning of resources, i.e. people, to cover the different projects' needs.

3.2 The development project at Sectra Imtec

The focus of Sectra Imtec was digital imaging and information systems for radiology, including both mammography and other x-ray applications. The development project that was followed dealt with the realization of a new film-free, digital, mammography system consisting of a unit for image acquisition and an administrative system called MDM (Micro Dose Mammography). The part of the MDM project that was followed was the software subproject with the purpose of developing software and acquiring hardware for both the administrative system and the acquisition unit. The MDM system was a new product for the company, especially the image acquisition part that was built with totally new technology.

The development project followed a commonly used software development philosophy called RUP (Rational Unified Processed). A basic philosophy important to Sectra Imtec was to keep a sound balance between flexibility and quality. What this means is that no quality levels were allowed to be neglected but there had to be enough flexibility in the model to allow for late changes. The products were developed with an annual cycle that allowed for a new release of the products every year, equal to one project. The control mechanism in the project was

basically built on change proposals which equal the requirements from customers or internal parties to be implemented in the product. The change proposals were controlled by a change control board that planned and prioritized the functions to be implemented.

Sectra had an outspoken strategy to hire well-educated people with a certain profile. 81% of the staff had an MSc or MBA degree or higher and the company had access to four professors and eight doctors in technology. People who could take own initiative with high grades, preferably in subjects like math, were particularly sought for. The work at Sectra was to a large extent characterized by a belief in the capacity and freedom of the individual.

4. Results

Engineers and designers are used to be confronted with problems or tasks and trained to efficiently finding solutions. Factors and present practice that might have affected the extent of explorative thinking in these solutions is one of the areas covered in this section. The second area is how the customer is represented in the development projects.

4.1 Present practice affecting explorative thinking

One difference between the two companies was the formation of design teams. Ericsson had a strong structure with formal design teams with cross-functional work of designers, programmers, testers and integrators grasping over a large sequence of responsibility. Since the complexity of products was quite high the impression was that both the design teams and individual designers are quite specialized. Within Sectra the option of building formal teams around specific parts of a project were not possible. People had to be able and ready to help out in almost any part of the design activities depending on how the priority lies. The most steps of the design was performed by the same person, including use-cases, design, coding and initial testing.

Within Ericsson specifications for the functions to be developed were broken down into quite big lumps to be dealt with by the different development teams. Due to the size of the company and the development model, the project manager within Sectra broke down functions to an individual level in approximately two weeks cycles. This meant that each designer knew exactly what he or she was supposed to perform within the next two weeks and where the responsibility lied to manage this task.

People within Sectra gave the impression to have a more pragmatic view on change which is exemplified by the following statement from a designer:

> *" ...as a designer you have been accustomed to that a lot of things could happen, changes can occur or that things get new priorities…You might need to adjust yourself pretty fast."*

The work climate within both companies must be characterized as open and trustful where it was a normal and expected behaviour to help colleagues independent of the assignment. In the smaller company information as well as important decision makers were easily accessible. Specifications and solutions were easy to influence and have a dialogue around. In opposite to Ericsson, where the work relied on strict and extensive documentation and routines when it came to the input and specifications as well as the output from the teams. Although work was very much done individually within Sectra much problem solving was performed based on personal contacts and preferences in informal brainstorming sessions and discussions. The following answer to the question when a project could be considered successful illustrates the ambition level and way of thinking among the Sectra designers:

"It is when you can feel that you have really worked things through and when you have had the time to do those last things that you would like to fix"

More or less all respondents from Ericsson replied that interaction, co-operation and discussions were important parts in their problem solving. Although the situation was quite turbulent, indicated by e.g. problems with continuous changes of prioritizations and plans people still had a positive view of the future. The newly implemented way of working was experienced having negative effects on the work but still viewed as being more of an opportunity and evolution than a threat by at least half of the respondents.

4.2 Interaction with the customer

One of the reasons why the customer had such an impact at Sectra was the company's background as a consultancy firm. The project manager for the mammography project express the following on the importance of the customer:

" Enormous, it is so much easier to make things right if you understand what you are doing. It also gives enormous power when everyone understands the goals towards we are striving. In project team discussions everyone, including the designers, understand the business where the tools they are developing will be used"

The radio base stations developed at Ericsson lied much further ahead than mammography with new technology and where the customer or end-user could be of limited assistance in the development. There were also several layers of subprojects and projects and functions before the interface with the customer is reached, very distant to the designer. The specifications that reach the design project and designer are what are left after several steps of refinement and interpretations.

As a contrast the designer at Sectra often had access to the specific wishes from customers and had good knowledge and awareness of the customer's situation and business. All designers participated in the annual end-user meeting where representatives of the customer, physicians, nurses and administrators participated in both social and product related activities. As a complement it was mandatory to visit the customer sites at least twice a year to discuss experienced problems, wishes for changes and to understand the working situation of the end-users.

5. Discussion

The *size and complexity of the company and the organizational structures* set both limitations and create opportunities for innovation. A project with multiple levels of command and where the assigner lies far away from the individual designer easily fall into a mode of chasing and interpreting the content of available information. This was also reflected by the high levels of interdependencies between people. Since the privilege to formulate the goals lies elsewhere than among the members of the project there were little room for improvisation and opportunities to influence the anticipated solution. Much focus of the practice of product development and project management had to be put on control rather than questioning the purpose or goals which negatively influence creativity [7] in [6].

Innovation normally happens in the discussion and interaction between different views represented by the actors in a development project [15]. In the small organization all involved parties and information were easily accessible and requirements for new functions were encouraged to be questioned and criticized. Control in the small organization or project can be

executed more on a pragmatic level allowing that the direction of the project constantly changes and that project goals were agreed together with the participants.

Interviewees indicated that *the product or system in itself had a strong impact on the motivation.* The mammography system is obviously a product of certain importance to women in the world. It was further easy to have a concrete feeling and relation to the product since it was easy to visualize and interact with. A more abstract product as a mobile telephony system is much harder to feel connected to if you are e.g. a database designer within one of the subsystems.

Breaking down and *setting up work on a team or individual level affects innovation*. The team played a central role at Ericsson being the unit of planning for tasks and the set of colleagues to work with in a project. Intuitively one would say that this group of people would be a mechanism of supporting innovation but practice show that little effort was put on explorative thinking. The usual responsibility of a design team was to realize tested and verified functions as efficiently as possible. Exploring uncertain solutions with e.g. new technologies or methods, would only slow down the work and create more problems for the team. A strong team spirit could unfortunately promote looking for the known and proved solutions.

At Sectra the individual were in focus and the single responsibility promoted a strong ownership of the problem and could ensure a proactive approach in finding solutions. Proactive in the sense that the task is really scrutinized to find the most relevant problem area and evaluating different ways to solve the problem. There would be enough room for people with differing views, not needing to seek the group's approval. A lot of courage had to be shown by a single individual to face the level of risk it involves to find solutions other than the anticipated.

Both companies show an impressive base of primarily *engineers with a large ability for abstraction and problem solving*. Engineers are trained to use known tools in order to solve the assignment they are presented to not necessarily supportive of innovation. It is crucial that designers continuously find ways to keep updated with new technology and knowledge in the area to be able to question the present practice. Explorative endeavors were seldom possible due to e.g. the tight deadlines but also the loyalty of employees to prioritize fulfilling the project goals.

It is obvious that the *customer provided a very strong driving force and motivational factor* for designers. At Sectra the changes of functions or goals more or less exclusively tried to find ways to satisfy the customer needs. Having strong connections and dialogue with customers close to the operational tasks must be considered less beneficial for e.g. the exploration of new technology. There was very little incitement to search for more unorthodox solutions when the end-user needed a solution to quickly solve a problem. There is on the other hand a great difference to use direct input from end-users and to use market information as inspiration.

In an environment where the project is far from the customer the environment could be suspected beneficial for innovation but other obstacles make an entrance. In the case of the radio base station development there were too much ambiguity, meaning that too little information were available. Time plans, priorities and functions were constantly changing at the same time as new technology were being developed in parallel with new ways of working. What this means is that there were small chances for designers to find certain levels of slack or rest at mind which is necessary for explorative thinking.

6. Concluding Remarks

Considering the staff's capacity, engineers and designers with high levels of formal education, much could be done to enhance explorative thinking to reach more innovative products. In order to reach higher levels of innovation, the study suggests the consideration of the following aspects of how to run PD projects:

- Visualizing the product
  If a product or system is possible to imagine or create a mental picture of it seems easier to look at solutions from many alternative angles. It also seems to have a positive effect on motivation if the product can be discussed and described in concrete terms. Visualizing could also include how easy it is to see how the product could be used in practice, how the user would benefit from using it.

- Ownership of the problem
  It is necessary to point out the importance of individuality in an environment with strong teams. A strong team spirit could lead to a tendency to look for the easy and quickest solution to a problem. If the responsibility of tasks and problems is distributed to the individual it could be reasoned that the probability of reaching higher levels of creative thinking increases. This thinking assumes that the social environment support interaction, debates and the personal risk taking it involves to present unorthodox solutions.

- First hand input
  Within the two organizations clear differences in behavior could be seen when confronted to a problem or task. In the case where the input is transparent and key people are easily accessible the designer immediately go to the source if the information is unclear or does not make sense. This behavior is an important step and process to go through when confronted with a problem or task. To increase the chance of innovative thinking the energy is better used clarifying first hand information than speculating about secondary material.

- Arenas for reflection
  Reflection is important not only for innovation but for learning in general. A situation with too high levels of ambiguity seems to have negative effects on explorative thinking. The situation within development organizations in high tech industries is that several aspects are continuously changing in parallel, e.g. technology, organization, priorities and working methods. Reflection requires some level of protection from a chaotic environment, at least temporary pauses. It is necessary that enough focus could be spent on keeping up with new technology and knowledge instead of a one-sided loyalty to keep project deadlines, which could become a hindrance for competence development.

- The purpose of customer understanding
  It is a prerequisite for successful product development to have clear and stable customer requirements. If the focus is too heavy on the actual end-user the chance of being inspired to innovative solutions becomes smaller. The end-user is normally a good source for incremental adjustments on the product and functions. There is although not contradictory to innovation to have a deep understanding of the customer's situation and business. The difference is how that information is used, as background information or as the single source to track future product requirements.

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