

Working Situations in Product Development – A New Approach to Evaluating the Design Process

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Abstract

This paper describes a new framework for approaching and evaluating product development processes by using working situations as the point of entry, and by viewing contextual factors as a means to improve design effectiveness and efficiency for the concurrent enterprise.

The proposed way of achieving this is to actively configure working situations in order to ensure a better alignment between design goals, the underlying design process, design methods, and the contextual factors, including surroundings and technology. Design efficiency and effectiveness is ensured through a product program approach based on the concept of streamlining the design process by standardizing ICT tools to improve portability between working situations, and by differentiating the surroundings in order to configure value-adding environments capable of creating a collaborative atmosphere. The approach depends on finding ways of ensuring proper workplace configuration and adequate technology support in order to support design activities and processes.

Keywords

Contextual factors, transitions, workplace configuration, technology support

1 Introduction

Today's knowledge workers spend a tremendous amount of time on ICT related problems, on the average 1-1.5 hours on a weekly basis [Schreurs 2000]. These problems cause frustration, this point is illustrated by the number of people that yell at their PCs, about 70%, or physically attack them when they operate in a non-logical fashion, about 30% [Aagre 2000]. Frustration occurs when the ICT tools in use do not provide the adequate support that is needed to do the work in an effective and efficient manner. High technology is advanced, and in order to make use of the built-in functionality we have to learn how it operates. Still, most of us can hope to learn to use effectively only a fraction of the full range of possibilities offered. Partly, this is due to the number of advanced features offered that few users need in their daily work. But it is also due to poor usability; the functionality is simply not accessible to the user [Baumann, Bruce, 2002]. The rapid technological development drives the change in working processes and can lead to both positive and negative effects. Furthermore, development of technology is a social process in which the resulting technology cannot be separated from the actors engaged in shaping it [Levin 1997].

In terms of supporting design processes, the approach suggested in this paper is based on a viewpoint that other categories of artefacts and elements in our surroundings can introduce problems similar to those related to ICT, and that problems related to ICT and surroundings all belong to a specific category of contextual factors that should be recognized and configured properly in order to provide the necessary contextual support for the design activities and processes taking place. ICT problems are easy recognizable, due to the fact that they explicitly

interrupt the workflow of design processes, either by bringing the work process to a full stop, or by hampering the work portability between different working situations. Problems related to surroundings are not as easily recognized, the reason for this is that they usually have a different role – they do not hamper the process directly, but instead, a favorable configuration of surroundings can add value to a process by suggesting a specific mindset, support creativity by offering a stimulating environment, and so on. Surroundings thus play a different role than ICT tools, as these two categories offer different kinds of process support. This paper introduces a new way of evaluating the design process by suggesting a framework that takes contextual factors of the design process into consideration, with emphasis on supporting design activities by introducing methods for increasing work portability and configuring value-adding surroundings.

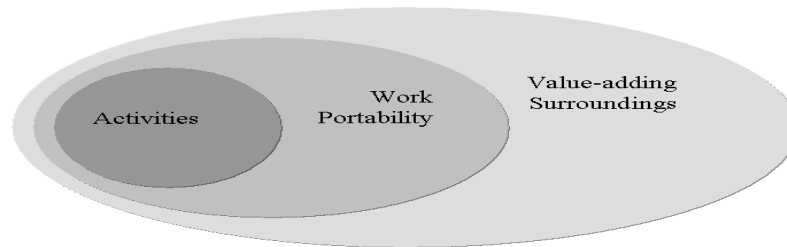


Figure 1: New model of activities and contextual factors

2 Traditional Design Methodology

Traditional design methodology is usually based on a best-case scenario, e.g. “when faced with this problem, apply this procedure” et cetera. However, this is usually more easily said than done. The reason for this is that the context in which the problem presents itself does not necessarily allow the problem to be solved in the prescribed manner. Hence, the context of the problem may introduce constraints that may limit the possibility of applying design methods according to their specifications. Put simply, one can say that method utilization depend on contextual support.

Design processes as described in the literature are complex activities. They typically involve activities and methods, tools, people, and different kinds of resources. In addition, they are always situated in a context of some kind. In this paper the contextual aspects discussed are related to surroundings, people and technology, or the spaces, human resources and artefacts designers surround themselves with. Designers are used to think in terms of tools that assist them in solving the problems they are dealing with. Similarly, they are aware of the fact that having access to human resources are critical to their problem solving processes. However, configuring their surroundings in order to ensure contextual support for the processes they are engaged in is normally viewed as being outside their domain. There is a need to define new evaluation criteria that does not only provide ways of ensuring close alignment between design goals, design activities, overall design processes, but also includes the contextual factors of the design process.

The process of design can be seen as “changing existing situations into preferred ones” [Simon, Schön 1982]. This definition is usually utilized when designing artefacts, but it can also be used when designing the *working situation*, where the design of artefacts takes place. Product development theory describes product development as a sequence of distinct activities. What are often described are *what* to do, and sometimes also a rationale explaining *why* this approach is necessary or suitable. However, a detailed description of *how* to perform a design task is often omitted. While problem solving can be described as a selection from available means, the one best suited to established ends, the broader concept of *problem setting*, where the decision to be made, the ends to be achieved, and the means which may be chosen, is often ignored [Schön 1982]. The activity of formulating and debating a design problem, where knowledge is represented as an open, multi-faceted problematic, is essential in product development. In this

paper the context of the problem is considered a part of this problematic. Hence, how to solve an ill-defined problem does not only depend on the character of the problem, but also on the situation in which the problem presents itself. Configuration of contextual factors in different working situations thus can be handled as a means to enhance the problem solving capabilities. This can be described as building contextual support for different processes that occur in product development. In particular, increasing the effectiveness of the design process through improving work portability between working situations, and increasing the efficiency of the design process by creating value-adding surroundings, are discussed.

According to Ulrich and Eppinger, the product development process can be described as “*the sequence or steps that an enterprise employs to conceive, design and commercialise a product*” [Ulrich, Eppinger, 1995]. The traditional, sequential, problem-oriented approach prescribes a logical cause and effect relationship between current design problems and how to solve the problem. The essential relation is between the problem and the standard problem solving method for that particular problem or group of problems. Lerdahl has described these context free methods as follows: “*The user context is then viewed as one of many rational criteria in the specification phase. Furthermore these methods try to be independent of the context in which the product is supposed to fit*” [Lerdahl 2001]. Hence, traditionally, external factors in product development have not been considered to be important. However, the product development is a very complex activity where the designer typically changes environment several times per day. The availability of tools and people, in addition to differences in the surroundings, change as the designer move from one working situation to another. Contextual factors should be treated as a mediating element in working situations. The framework discussed here suggests that the problem solving process should be a configuration of the best available problem solving methods or activities that are properly aligned with a supportive combination of contextual factors.

3 Contextual Factors in Product Development

Contextual factors in product development can be described as surroundings, people and technology [Kristensen et. al., 2002]. Different surroundings define the physical context of any design process. Different configurations of people within certain surroundings influence the way and how often we communicate with each other. Technology influences the way we perform tasks related to any design process by introducing new opportunities and new ways of communicating, exchanging and sharing information, and the way we conduct other tasks. In addition, technology enhances the functionality and adds flexibility by making it possible to perform design activities independently of time and location.

3.1 Surroundings

The physical domain, or what we normally perceive as surroundings, is powerful in terms of supporting a feeling of presence and real time collaboration, and for communicating through effective, large-scale visualization and the use of body language, which can trigger many senses simultaneously. Surroundings thus provide a broad, shared framework for any process which can add value to a process by acting as a platform for shared mental models, and a feeling of presence, trust and close collaboration.

3.2 Surroundings Combined with Technology

New technologies offered today can provide a bridge between what is normally perceived as being a part of our surroundings and what we normally would refer to as technology. By making better use of such technologies and by adapting them to the design goals it is possible to obtain a continuous spectrum of surroundings and technologies that combine favorable characteristics of suitable, value-adding surroundings and well-adapted technologies that increase work portability across different working situations.

Two of the most promising new technologies that both can be categorized as a part of our surroundings and at the same time a part of the technology in use, are electronic whiteboards and projectors, as these provide input and output channels that facilitate the transition from large-scale visualization to digital files with high portability.

Another advantage of large-scale technology-based interactive surfaces placed in our surroundings is that the input and output surfaces remains the same, and this is well adapted to the favorable process that takes place during engineering design, where the designer actively reflects on his or her own design process [Schön 1982]. On the other hand, the use of virtual communication tools such as virtual workspaces and data conferencing tools increase steadily. As much of the designers' interaction with others happen through these channels, it is therefore becoming increasingly important to integrate these technologies in the physical context, as a natural part of the surroundings. This is described below:

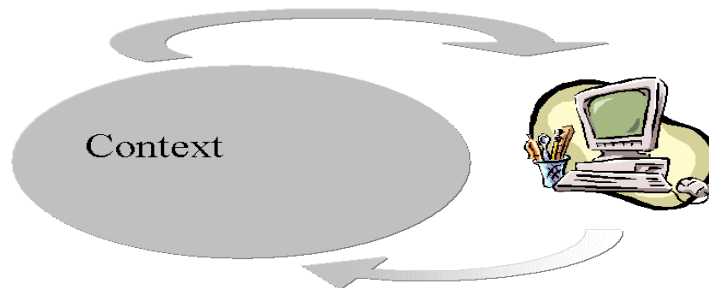


Figure 2: Integrating Technology and Surroundings

First, it is important to ensure adequate functionality in the virtual workspace by subtracting important characteristics from the physical environment in order to increase the usability of these workspaces by using familiar terms and expressions known from our surroundings, such as room metaphors et cetera. This process can be described as giving virtual workspaces physical characteristics, and this process has been in progress for some time, as recent virtual workspaces usually come bundled with a wide variety of different tools, often with familiar labels known from physical surroundings. Second, it is important to effectively position the virtual workspaces in the right context, and build an understanding of the relations between the virtual workspaces and the environment they are operating in, or the designer interaction space. In particular, this can be accomplished by making use of technologies with combined characteristics, such as digital whiteboards that combine excellent visualization characteristics with virtual characteristics, such as the ability to share information effectively over distance, et cetera. Such a set-up can support both work portability and create a favorable value-adding atmosphere that can be configured to effectively support a variety of processes such as creative sessions, analysis, or decision-making.

4 Working Situations – Basic Concepts

Working situations describes the configuration of design methods and activities, design process, and contextual factors. These are all interrelated, and the relations are shown in figure 3. Working situations occur within the framework of the designer's interaction space. Different working processes typically have different key configuration characteristics, based on external constraints and requirements and individual problem solving preferences, in addition to those introduced by the contextual factors people, technology and surroundings, which define the context of any given task-oriented working process.

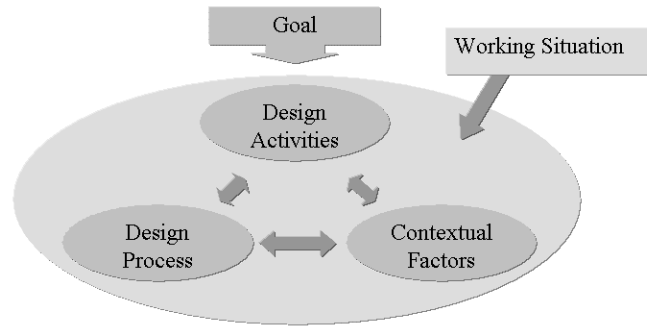


Figure 3: Working Situations, Conceptual Framework

During a typical working day, engineering designers find themselves busy doing individual design activities on their workstations, searching for information using the web and other resources, receiving and making several phone calls, sending and receiving a number of emails, meeting with visitors in their office landscape, and interacting informally with peers and customers in project meetings. In addition, they make informal sketches on a whiteboard or a piece of paper to clarify certain design aspects, perhaps as they meet colleagues by the coffee maker. They also make presentations and collaborate with others using chat, data conferences, and then save their work in virtual workspaces in order to make their latest updates available to others that are working on the same projects. As described above, the design process is indeed very complex, and it is often difficult to categorize the different sub processes that are taking place in the overall product development process. Designers often find themselves in situations that do not fully support the processes they are engaged in. Often there are discrepancies between the requirements of the problem and the solutions the current situation has to offer, which can reduce the efficiency of the design process. These discrepancies can be described as misalignments between goals, design methods, overall design process and contextual factors. These should all be adjusted in such a way that they are compatible with the overall goal. In these instances, it may become necessary to change the configuration of the working situation.

4.1 Usability of Working Situations

ISO 9241 part 11 defines usability as “The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.” Although defined for products, this definition can be used to illustrate the importance of having access to a context, in which to perform design activities, that is usable. Design processes should also be effective, efficient, and provide some level of satisfaction for the designer. A usable working situation broken down into its components could thus be defined as one that is usable in terms of providing understandable design activities arranged as a design process, in a pattern that is comprehensible for the designer. Furthermore, the team configuration and essential technology necessary to perform the desired activities must be usable. Finally, the remaining aspects of the context, the surroundings, should also be usable in terms of adding value to the process.

4.2 Efficient Use of Working Situations

A new approach is proposed that is based on the use of working situations as the main perspective where surroundings, people, technology and design tasks are considered a part of the same, holistic framework, and where the significance of contextual factors are acknowledged and emphasized. Important aspects of this approach include gaining an understanding of how to make effective use of the visualization potential in active and passive spaces, how to act in accordance with people and their presence, and how to create atmospheres that support creativity and decision-making through motivation. This leads to a new perspective proposing a situation-

based approach where the designer actively reflects upon the different design situations he or she is exposed to.

5 Evaluating Working Situations

When evaluating the design process in terms of its likelihood of fulfilling existing design goals, there is a need for a broader perspective, one that takes into consideration the entire working situation, including contextual factors and their configuration. Below, important aspects of the contextual configuration dealing with surroundings and technology are discussed, namely how to control positive and negative variety in working situations, in particular how to manage surroundings and ensure adequate work portability.

5.1 Increasing Positive Variety through Creating Value-adding Surroundings

Surroundings should be treated as a design resource or a design input factor, in particular because of its potential for creating a favorable working atmosphere. The common office configuration may be suitable for some processes, but is less adapted to others. Many people experience this when they get a creativity boost when being on seminars, or perhaps when travelling. Some of this may be related to just being exposed to new environments, but some of it is also due to the particular setting that is present. Many problems can be traced back to poor surroundings. There should therefore be a close alignment between process and surroundings. This requires reflection, designers should actively reflect upon the working situation and the contextual configuration they are engaged in. One way of approaching this challenge is to define work zones with different characteristics, keeping in mind how to use information technology as an integral part of the context. This is a way of increasing what can be labelled as positive variety, adding value to and providing contextual support for a wide variety of different design processes.

5.2 Reducing Negative Variety through Improving Work Portability

As for surroundings, information and communication technology should also be considered a design resource. Traditionally, ICT tools have been known for assisting design specific design activities and methods. In addition, ICT tools should be recognized as tools improving design performance because of their work portability-enhancing characteristics.

Using technology to improve portability is a way of streamlining the design process through making it possible to move effortlessly between different working situations without losing momentum. In order to obtain this, it is necessary to set up a system of ICT tools that can effectively and efficiently capture, store and display information quickly, and at the same time making this information available for globally dispersed teams. It is therefore a requirement that all information is stored digitally, even though the input was manual and on paper or a whiteboard. Electronic capturing devices as automatic scanner systems, digital cameras and interactive whiteboard systems are thus of special interest, as these can facilitate the transition from co-located collaboration to computer-mediated collaboration through for instance data conferencing systems.

5.3 Using a Product Program Approach

Working situations can be configured using a product program approach, focusing on improving positive variety, or variety that adds value to a particular situation, while changing negative variety, or variety that causes confusion and reduce the effectiveness of a particular situation, into commonality [Aasland, Stormo, 2002]. By using such an approach, it is possible to combine surroundings and technology for flexible team configurations, and support effective and efficient collaboration in globally dispersed teams. This is obtained by tool standardization, by giving the

physical surroundings digital properties, and by creating a feeling of presence over distance. This can bridge co-located and dispersed team configurations in a favorable manner.

As shown in figure 4, working situation adaptability is improved through traditional measures as method and process improvement, and in addition by increasing the use of value-adding surroundings and by increasing work portability through the use of standardized ICT tools that can be incorporated in the surroundings.



Figure 4: Working Situation Adaptability

6 Case Study

A series of case studies in graduate course SIO2043 Machine Design and Mechatronics at Department of Machine Design and Materials Technology at NTNU [Fyhn et. al., 2001, Hildre et. al., 2000], has shown that there are differences in how product development activities are carried out, depending on the working situation. This was particularly important during real time activities, both for co-located and dispersed teams. Special attention was paid to contextual factors and applications in fields such as concurrent engineering and concurrent enterprising. In these case studies, there were strong indications that contextual factors and the way these were configured had a significant impact on both the overall design process, the design methods, and the activities the student were engaged in. The team configuration influenced the tools in use, which in turn affected both the overall design process and the different design activities.

7 Conclusions

There are clear indications that knowledge workers do not exploit the potential of actively using their surroundings as a design resource, and that the level of working situation reflection is very low. Contextual factors should be treated as a resource, as surroundings have the potential of adding value to a process when configured properly. Technology, on the other hand, adds transition capabilities when configured properly. Observations based on approaching and evaluating the design process by using working situations as the point of entry, has shown that different configurations of surroundings, people and technologies can be adapted to different design methods and activities, besides providing contextual support for different design processes. Viewing contextual factors as a means to improve design effectiveness and efficiency introduces new possibilities to improve work portability and to add value to the design process.

A series of case studies has shown that there are clear indications that an increased awareness of the role of working situations in product development will improve the utilization of the principles of concurrent enterprising. This is particularly important for working situations dominated by real time collaboration. Contextual factors should be configured and manipulated in order to provide adequate contextual support for the networked enterprise, in order to improve collaboration across different projects, working situations and locations.

8 Further Research

Suggestions for further research include defining a framework where the contextual factors are made tangible. There is a need to define the relations between virtual workspaces, surroundings and different team configurations. There is also a need to establish a set of criteria, which can serve as guidelines for configuring working situations. Combined, it is then possible to make tools and methods for configuring suitable working situations as a function of goals and available activities, processes, and contextual configurations.

Furthermore the dynamics of working situations should be explored, in order to understand the transition mechanisms between different working situations and how to avoid the lag or delay between the point where the working situation does not provide sufficient contextual support, and the point where the designer discovers this, and decides to make the necessary adjustments by configuring new working situations.

References

- Aagre, Audun; Computerworld: Skjeller ut datamaskinen. WWW page.
<http://web1.computerworld.no/cwi.nsf/Alle/0298136714F8D817C1256877002A0D00>, accessed 01.03.2002.
- Aasland, Knut; Stormo, Silje: Product Program Development – A Case Story from a Kitchen Manufacturer. Proceedings of the 9th European Concurrent Engineering Conference, 2002, pp. 21-25.
- Baumann, Konrad; Thomas, Bruce: User-Centred Design of Telecommunication Products. Proceedings of the 9th European Concurrent Engineering Conference, 2002, pp. 195-201.
- Fyhn, Håkon; Kristensen, Kjetil; Hildre, Hans Petter; et al. “Produktutvikling i det virtuelle rom.” Research Report, Department of Machine Design and Materials Technology, NTNU, Trondheim, Norway, 2001.
- Hildre, Hans Petter; Feilberg, Julie; Fyhn, Håkon; et al. “IKT i læring.” Research Report, Department of Machine Design and Materials Technology, NTNU, Trondheim, Norway, 2000.
- ISO standard: Ergonomic requirements for office work with visual display terminals (VDTs), Part 11: Guidance on usability, ISO 9241-11:1998.
- Kristensen, Kjetil; Hildre, Hans Petter; Sivertsen, Ole Ivar; Fyhn, Håkon; Storler, Klara: Working Situations in Product Development: Linking Technology, Contextual Factors and Design Tasks. Proceedings of the 9th European Concurrent Engineering Conference, 2002, pp. 161-165.
- Lerdahl, Erik. Staging for Creative Collaboration in Design Teams. Doctoral Thesis, NTNU, Trondheim, Norway, 2001.
- Levin, Morten. Technology transfer is organizational development: an Investigation into the relationship between technology transfer and organizational change. International Journal of Technology Management, Vol.14, 1997, pp. 297-308.
- Schön, Donald: The Reflective Practitioner. Basic Books, New York, NY, 1982.
- Schreurs, Nard; Computerworld: Pc-aggresjon øker stress. WWW page.
<http://web1.computerworld.no/cwi.nsf/Alle/079C38BD30AA6210C12568A90022534C?OpenDocument>, accessed 01.03.2002.