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# COMMUNICATION AND KNOWLEDGE SHARING IN DISTRIBUTED ENGINEERING DESIGN

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## 1. Introduction

Even more companies are forced upon product development in spacial separated teams. Major enterprises have often more than one engineering design teams indoors or even placed in several locations all over the world. In addition companies often develop together with suppliers and external consulting teams. This kind of design work differs in many ways from the conventional developing. One main difference is that communication evolves to a key feature of concurrent engineering [Ullman, 1997]. A significant part of the working hours is spent with the organisation, communication and managing the collaboration of the teams. For the most effective arranging of collaboration, all team-members should possess a corporate knowledge base. However, this is unfortunately impossible, therefore communication as well as the management and sharing of knowledge and information is necessary to maintain the collaboration.
Schueller and Basson [Schueller, Basson, 2001] present a framework for distributed engineering design (figure 1). Design methodology guides designers through the design process. Communication and information transfer is needed to co-ordinate and perform teamwork. Input devices support both design work and communication.

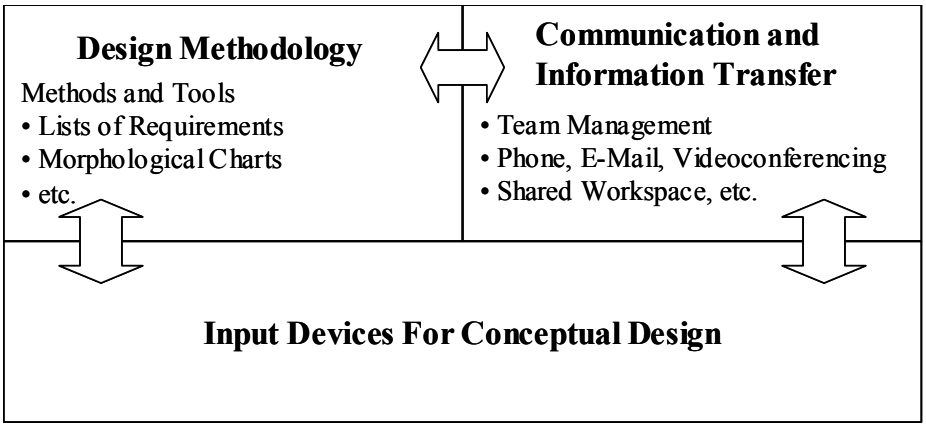


**Figure 1. Distributed engineering design environment**

## 2. Knowledge management – state-of-the-art

This framework shows that information and knowledge transfer are particularly important for developing in distributed design teams. Companies try to implement knowledge management systems to support the teams effectively with information and know-how. The main objectives to achieve with

knowledge support are: reduction of development time, avoiding the "reinvention of the wheel" by maintaining knowledge in the enterprise and create a better system for knowledge distribution.
However, a study shows that these objectives are not yet reached. The results of the study [Doering-Katerkamp, et al 2000] show that the majority of enterprises took the topic of knowledge management into account as late as 1999. Although all enterprises regard knowledge management as important, the main problem is that the majority does not have a clear idea what the meaning of knowledge management is. This fact even applies to the 40% of companies, which already began a respective project. Most of the problems during the implementation are the lack of acceptance by the employees and difficulties when preparing and structuring the knowledge. In order to understand the reasons of these problems, the term *knowledge* should be described.

### 2.1 Meaning of knowledge

All examined descriptions of knowledge [Merz 2000; Heinsohn 1999, Vajna 2001] seem to have two aspects in common: Knowledge is always attached to humans and it is created when the information is set into a context of experience.
However, a problem is that knowledge consists both of explicit and implicit parts [Merz 2000]. Anything that can be represented by words, analytically, or in equations is explicit. These explicit components can be formulated as rules. However, rules can never cover each aspect of knowledge. In each case rules represent only an excerpt of knowledge.
In contrast, implicit knowledge - as the name already implies - cannot be described externally. The importance of these components shows that human creativity and experience, decisions, analyses, perception principles, and understanding principles stay mostly implicit [Radermacher 2001]. Knowledge processing in a real world environment cannot be described holistically by explicit mechanisms alone, without the implicit aspects.

### 2.2 Knowledge sharing - communication

The stated objectives of knowledge support are the optimal provision of design knowledge and the storing of this knowledge within the enterprise. However, the limitations described above state that knowledge and experience cannot be made completely external; they cannot be stored outside of the human brain. How can this contradiction be solved?
Knowledge itself cannot be documented, but the process of knowledge sharing by communication is suitable for it. If the communication is documented, other persons can use the information later on. By processing the stored information another person can induce similar knowledge from this information.

## 3. Pro-Teach-Net

The specialities of communication in distributed engineering design were analysed within the scope of a national research project. The project called Pro-Teach-Net is implemented by five German universities. Objective of the research project is to generate an educational network for product development and engineering design [Zirkel, 2002]. For this purpose a multimedia-based learning system is established based upon the net-based platform WebCT. Diverse partitions of engineering design (machine-elements, design methodology, etc.) are stored in a modular structure. Contents of these modules are similar to the corresponding lectures. However, due to the multimedia-based environment this content is represented heterogeneously, for instance as texts, animations or videos. This multiple representation helps to increase the quality of learning process.

### 3.1 Distributed engineering design project

Learning-by-doing is especially important in the context of engineering design. Therefore the realisation of a collaborative engineering design project is provided within the learning program. The first design project was implemented with the collaboration of 6 student groups. The task for the 20 students was to develop a packaging machine for shrinkable tubing within 4 months. As starting data the students got a task description and a few requirements. All teams had to prepare a separate list of requirements. These lists were then integrated to a collective requirements list. Furthermore, design

variants had to be worked out. After the evaluation and selection of the variants each team had to detail one or two modules of the best variant. At last the finished modules had to be assembled in a virtual meeting.
At the beginning of the project, the students got together at a kick-off meeting to define the subtasks and to organise the communication. For the technical support of the cooperation the platform WebCT was applied. This platform offers a number of synchronous and asynchronous communication and file exchange possibilities: chat, email, forum, whiteboard, download, and file exchange.

### *3.1.1 Virtual meetings*

Beside these tools of the platform, the external conferencing tool "Marratech" and the CAD collaboration tool "OneSpace" were applied. By means of these tools virtual conferences has been organised on several stages of the project. Aims and requirements of real-time virtual conferencing in distributed engineering design are described by [Kufer, 2002]. By his description main alternatives in conferencing are video conferencing, audio conferencing and application sharing.
Marratech offers an effective multi-point audio and video conferencing possibility. After carefully setting both microphone and headphones level, and using accurate hardware, a good sound quality without delay could be achieved. Other tools of the software like document visualisation or chat have been seldom used.

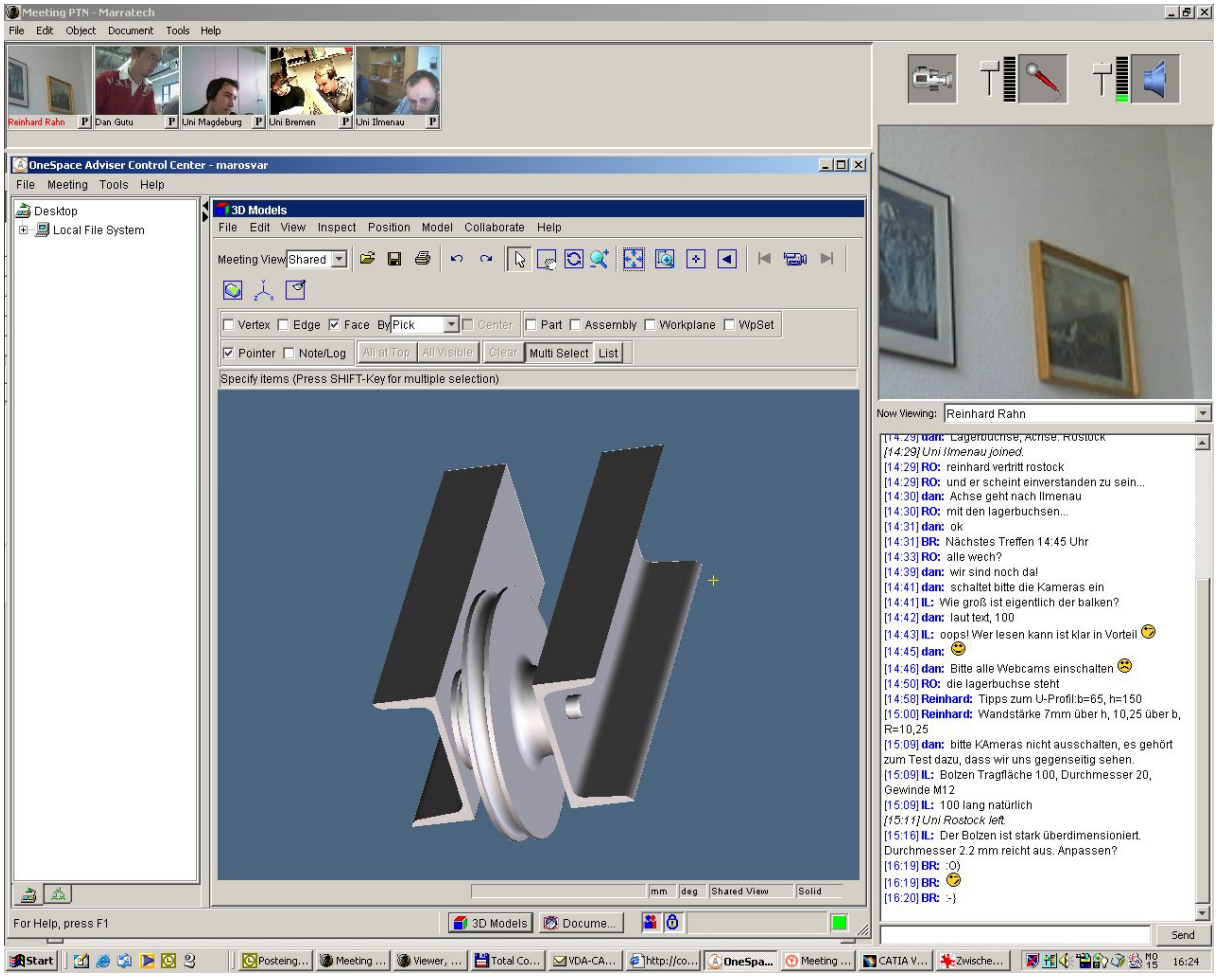


**Figure 2. Live assembling via CAD-collaboration tool and videoconferencing**

In later phases of the design process OneSpace has been applied for checking and assembling the CAD parts. This software enables a visualisation and modification access on the uploaded parts for all clients. Therefore a previous harmonisation of modifying activities between the participants were

necessary, to avoid the parallel modification of one part by more designers. OneSpace can be effective applied for checking and assembling of designed parts. However, the modification of CAD parts within OneSpace has disadvantages. Due to converting parts into neutral formats for uploading into OneSpace, the parametrics will be destroyed.
Our experience is, that for running these two software parallel, a Pentium 4 processor and 512MB RAM is necessary. Otherwise, there were no bandwidth problems between the participating universities. Figure 2 shows the usual tool set of videoconferencing. Personal discussions were made via live pictures of the other members. Parallel the assembling and checking of the CAD models could be carried out.
A partial objective of this project was the investigation of communication in a virtual environment. In order to evaluate the results easier only the above-mentioned electronic communication tools – although without regulations or delimitations – could be employed. The assessment of communication was done both objectively and subjectively. At first, the access frequency of the electronic tools was determined. That gives an objective view about the flow of communication. A survey on the co-operation reflected the subjective opinions of the development teams on their communication.

## 4. Conclusions and suggestions for improvement

### 4.1 Results of the survey

The results confirm the opinion that the focal point of distributed product development is communication and task sharing. In the student's opinion communication and organisational tasks were more problematic as the real design tasks. Furthermore, communication was classified as particularly time-consuming. The students spent 40-60% of the entire working hours with communication. This value corresponds with the results of previous surveys [Sainter, et al 2000; VDI-EKV 1992].
The most frequently used tools of the communication platform were forum and chat. The students had to indicate the importance of the tools in the survey. According to their response the most important tools were forum 80,5% and chat 80,5% (fig. 3). Both synchronous and asynchronous information exchange took place by the majority by communication tools which were accessible to all members. Personal e-mails or data-transfer from person to person were rarely applied. This contributes to the correct distribution and provision of information and experiences.

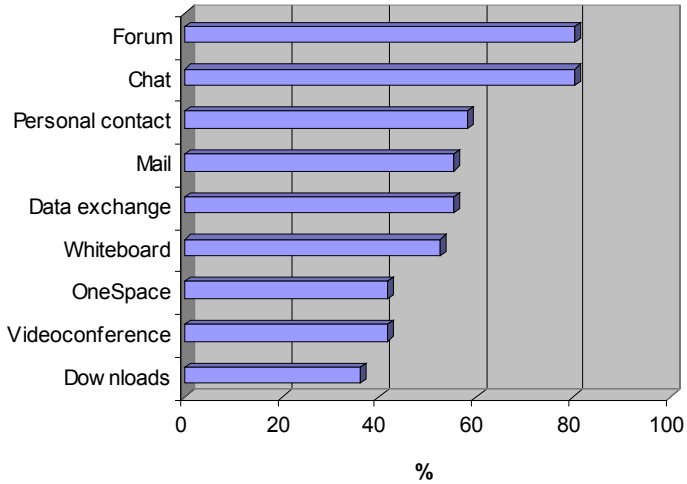

**Figure 3. Importance of communication tools**

Gomes, et al [2001] summarised the experiences of a distributed engineering design project. Their consequence is, that a personal kick-off meeting is essential for distributed engineering design projects, to enable an efficient communication of the teams. Also [Eckert et al, 2001] describes, that

people with personal contact work together more effectively. Our results are similar. All participants agreed on the necessity of more personal meetings besides a personal kick-off meeting.
The overall view of participants was that the available tools are not sufficient for an optimal collaboration. 77% of the student would have been glad to use other communication forms (most frequent wishes were telephone and electronic messenger services). The importance of human resources and interactions in collaborative engineering design is underlined by the fact that innate experiences and group-internal discussions were indicated as the most important source of information (fig. 4).

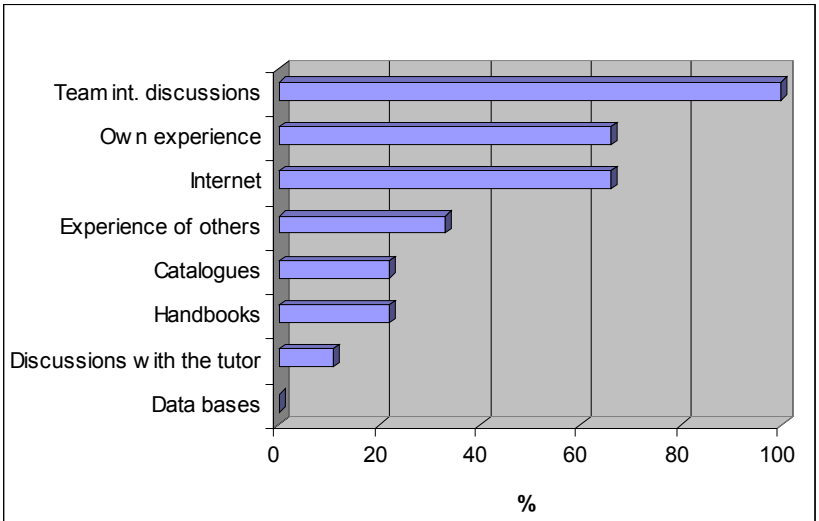


**Figure 4. Importance of information sources**

### 4.2 Conclusions on communication tools

Communication via chat offers a beneficial possibility for synchronous collaboration. However, finding related information in the recordings is time-consuming. Therefore chats should be journalised. All declarations and agreements have to be prepared easy-to-find for the participants.
Similarly difficult is to retrieve articles within the forum. For an optimal adaptability of the forum a logical structuring of articles and categories is necessary.
Another problem occurred because of the asynchronous character of electronic forums. Sometimes it takes several days to get a question answered. To avoid a delay of the design project the frequency of using the forum should be regulated.

### 4.3 Conclusions on distributed engineering design process

Gomes et al [2001] described some advices for sharing design tasks. In our project we took these advices, but sharing the task still have been left the most problematic step for us. In the early phase of clearing the task there exist only an objective of the product, but nothing tangible – no structures or modules of the machine – to share.
Another difficulty caused the lack of a uniform design methodology. Each university teaches various design approaches, so it was difficult to compare and rate the design versions of the teams.

## 5. Summary

Managing of knowledge is necessary within the area of product development in order to remain competitive. However, the implementation of this philosophy is not fully developed yet. Today the main problems with handling knowledge are the insufficient communication between the employees and the deficits in the generation of knowledge. Only humans have the accomplishment to generate

knowledge on the base of experiences. The advantages of computers can be exploited by using them to compensate for the handicaps of humans by storing and sharing knowledge and experiences.
Communication is a determining component of collaborative engineering design projects. Electronic communication tools exclusively are not sufficient for an effective collaboration. The personal communication of the participants have to be enabled. Furthermore, today's electronic tools need to be upgraded.

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