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2001

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### *Citation for published version (APA):*

Blomé, M., & Odenrick, P. (2001). *Computer supported visualization to support continuous improvements within quality systems*. 135-143. Paper presented at Proceedings of the Fourth International Conference on Stimulating Manufacturing Excellence in Small and Medium Enterprises (SMESME), Aahlborg, Denmark.

### *Total number of authors:*

2

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# Computer supported visualization to support continuous improvements within quality systems

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## *Abstract*

This paper presents a study wherein computer supported visualization is used to design and enhance understanding of quality systems. The study attempts to discover if a quality system such as ISO 9000 can be visualized, and how the visualization should be designed in order to support continuous improvement. Three companies in southern Sweden have set up special groups (here called design groups) whose purpose is to establish principles for models to visualize their quality systems on the Intranet. Their goal is to find a web-based solution that eliminates problems with updating documents, but that also supports understanding as well as reflection about how to improve existing routines and workflows. The design groups create and evaluate computer supported prototypes and exchange ideas via the Internet. The companies prefer descriptions containing local symbols (pertaining to just their company) that connect non-physical aspects, e.g. communication, with the physical environment. They also prefer the use of pictures as much as possible, since this makes the context more understandable. A quality system based on visualization will have better possibilities to engage personnel in the quality work; it will be faster, easier, and more interesting to use than systems with paper documents or other text based systems on the intranet.

## *Keywords:*

Visualization, quality system, ISO 9000, participation, Internet.

## **1. Introduction**

Technical developments and rapid market changes encourage companies and their personnel to benefit from the dynamics and diversity that occur. To be successful, companies will have to have a creative tension between the vision and the present reality (Senge, 1990). Thus companies have to find the balance between creativity and routine, and between chaos and structure.

Increasing numbers of companies try to structure and improve their organization according to the ISO 9000 standard. The ISO 9000 standard is a tool to improve the organization and its quality system. The quality system is the organizational structure, procedures, processes and resources needed to implement quality management (Standardiseringen i Sverige, 1999). ISO 9000 recommends a process approach for quality management. General demands are that the organization should establish, document, implement, maintain and continuously improve a quality system that fulfils the requirements for this standard (Standardiseringen i Sverige, 1999).

An effective continuous improvement process in a company should be based on participation, i.e. where the personnel have possibilities to affect the improvement process (Johansson 1997, Berling et al 1998, Gontijo and Odenrick 1999). An improvement process can be understood as a collective learning process where different viewpoints are considered. This demands understanding and an ability to interpret and reflect upon the information among participators with different backgrounds (Dixon, 1994).

Visualization can be used as a common language and thus support the learning and improvement process within a mixed group of participants. Visualization with dynamic pictures, e.g. 3D drawings of production environments and simulations of production flow, has proved to increase the amount of suggestions from blue-collar workers in discussions (Akselsson et al 1990, Bengtsson et al 1996, Rassner and Odenrick 1999). Non-physical (hereafter called Immaterial) aspects of work such as information flow and communication have been visualized and shown to increase the understanding of individual responsibility (Blomé 1998). An interesting question is if the ISO 9000 quality system can be visualized. Also, how should the visualization be designed, and what should it look like in order to support continuous improvements.

Three companies (here called A, B and C) were chosen for the study at hand where visualization was used to enhance the understanding and effectiveness of their quality systems, all of which are set up according to ISO 9000. Company A has 37 employees (25 blue-collar workers), Company B has 9 employees (4 blue-collar workers) and Company C has 51 employees (35 blue-collar workers). Their existing systems consist of a book, the quality manual, where routines are described by text. The companies would like to instead develop a web-based solution that facilitates updating documents, but that also leads to understanding of the organization and how to improve existing routines and workflows.

The aim of the present study is to find out if a quality system such as ISO 9000 can be visualized, and how the visualization should be designed in order to support continuous improvement, with special reference to small and medium size enterprises.

## **2. Methods**

### *Procedure*

The study presented in this paper was conducted as a result of feedback and discussions based on Kolb's model, which is based on Lewin's theory on experiential learning (Kolb, 1984). The study was inspired by Lewin's action research focusing on participation and social action (Ohlsson and Granberg, 1998). The search for possible approaches to visualize processes started with a separate literature research, and a pilot study with 18 students from the Lund Institute of Technology, and was then followed by field studies within the three companies.

The pilot study was based on experiences from a different study with students from an art school (Forsgren et al, 1990), but further developed to focus on immaterial flows and processes. The pilot study consisted of 18 students assigned to visualize each of the three sectors communication & information, responsibility & authority, and knowledge & experience. The 18 students were divided into three groups of six each. Each group was to visualize the immaterial aspects from one of the three perspectives individual, group or company. The students explained their visualizations when they were collected.

Based on the results of the pilot study and a previous case study (Blomé, 1998), a number of visualization examples were made. The examples consisted of linked web pages with symbols and text.

These examples were then presented to key persons from the three companies. The companies were of small or medium size and had already established a relationship with the authors in earlier projects. It was decided that the visualization should focus on the ISO 9000 quality system.

The research project was presented to the personnel in the companies and a questionnaire was handed out to examine how they perceived their quality system. A web page and a notice board presented the results of the questionnaire to the personnel. The results were further analyzed within a special group (here called a design group) in each company and discussed related to

the research project. Each design group consisted of representatives from different functions of the organization together with the research project representative:

- Company A representatives: The quality manager, and occasionally other personnel.
- Company B representatives: Three, occasionally four persons including the quality manager.
- Company C representatives: Four persons including the quality manager.

The design groups attempted to find principles for a model to visualize their quality system on the Intranet. The design groups produced suggestions by sketches supported by documented material in the quality system and also by the members' experiences of visualization of information. At the first meeting, the participants individually reflected and sketched on how the contents of the quality system could be visualized. The ideas were then discussed (and tape-recorded) within the group, and the sketches were explained and/or modified. The ideas were then visualized by using a computer program. These visualizations produced three prototypes of the study.

During this process, the suggestions were published on a web page which all three companies had access to. The ideas were presented, discussed and further developed at subsequent meetings within the design groups. Each new or improved suggestion was published on a web page.

In these meetings, the research project representative initiated discussions and coordinated the objectives and thoughts among the participants of the different design groups.

#### *Documentation methods*

Audio tape-recording of interviews and discussions and questionnaires were used to document the research process. Material produced, such as sketches, ideas and suggestions, were collected. The material published on the Internet was recorded on CD during the study.

### **3. Results**

#### *Literature research*

An overview of a process where the basic terms, e.g. input-transformation-output, are exemplified, can be described with figures of people, buildings and products (Bruzelius and Skärvard 1995, Nilsson 1999). More detailed processes and relations are described by geometric symbols, e.g. boxes and circles, with text connected by arrows (Bruzelius and Skärvard 1995, Harrington 1991, Klefsjö et al 1999, Rehnman 1970, Rentzhog 1996)

#### *The pilot study*

The pilot study revealed basically three approaches to visualize the immaterial aspects studied:

- a. A first approach was to visualize the immaterial factors by a scenario with one picture. The scenario describes a happening or a case where figures with talk bubbles think, speak or act in an environment. This kind of description was chosen in 16 out of 54 visualizations (Table 1). Figure 1 shows an example of how communication & information from a group perspective could be visualized.

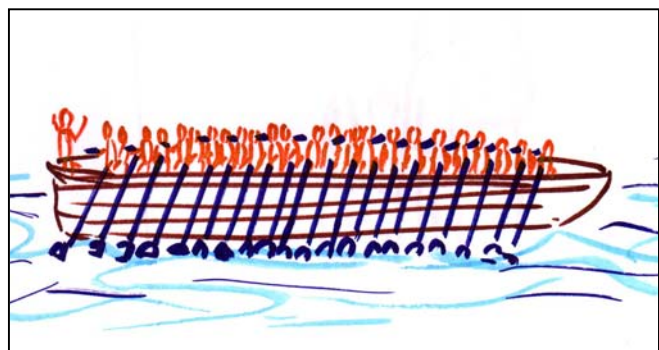


Figure 1. Example of Approach a – a scenario with one picture.

b. A second approach was to describe the immaterial factors as relations between different components connected by lines and arrows (Figure 2). The different components were represented by symbols and geometrical or metaphorical figures, with or without text. Arrows and lines showed directions and connections between different boxes or symbolic figures. This kind of description was chosen in 32 out of 54 visualizations (Table 1). Figure 2 shows an example of how communication & information can be visualized from a company perspective.

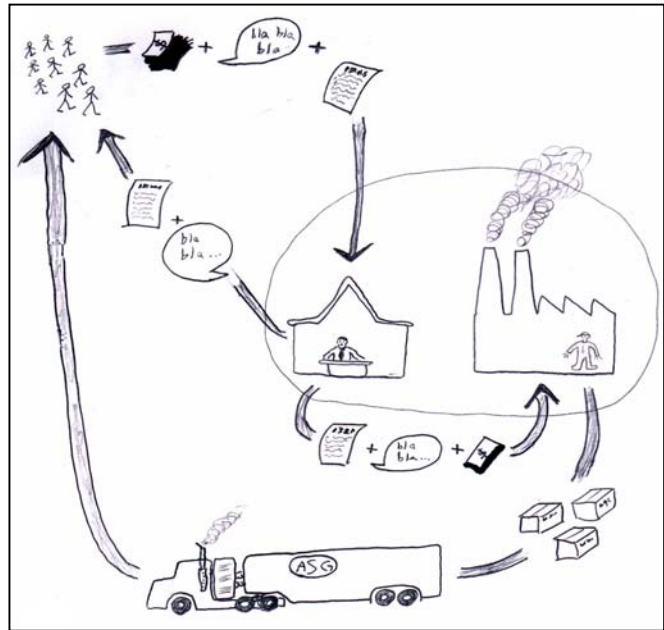


Figure 2. Example of Approach b – different components connected by lines and arrows.

c. A third approach was to visualize the immaterial factors by combining scenarios and components connected by lines, i.e. Approach a and b (Figure 3). This kind of approach was chosen in 6 out of 54 visualizations (Table 1). Figure 3 shows an example of how communication & information from an individual perspective could be visualized.

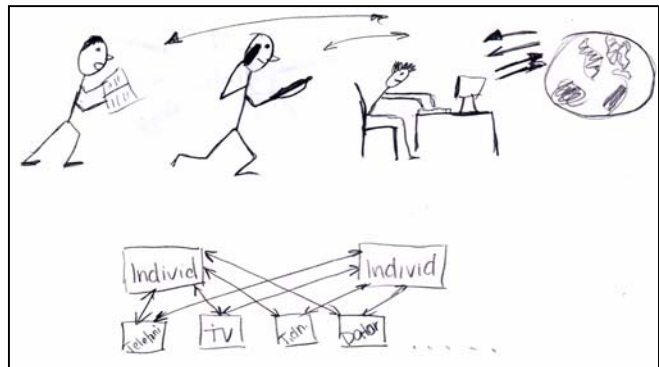


Figure 3. Example of Approach c – a combination of scenarios and components, i.e. Approaches a and b.

Immaterial aspects	Perspective	Approach			Total	
		a	b	c		
Communication & Information	Individual	0	4	2	6	18
	Group	2	3	1	6	
	Company	1	5	0	6	
Responsibility & Authority	Individual	3	3	0	6	18
	Group	3	3	0	6	
	Company	2	4	0	6	
Knowledge & Experience	Individual	1	4	1	6	18
	Group	2	3	1	6	
	Company	2	3	1	6	
<b>Total</b>		<b>16</b>	<b>32</b>	<b>6</b>	<b>54</b>	

Table 1. Eighteen students visualized each of the three pairs of immaterial aspects according to Approach a (a scenario with one picture), Approach b (as relations between different components connected by lines and arrows) or Approach c (as a combination of approach a and b).

*The field studies*

Table 2 shows the results of a questionnaire that was handed out to the personnel at the three companies. Thirty one of 37 answered at Company A, 9 of 9 at Company B, and 43 of 51 at Company C. Company A does not have a quality system manual since they were not certified yet, thus the first question was left out.

Questions	Company	Answers				
		Very good	Rather good	Neither good nor bad	Rather bad	Very bad
How does the quality manual function?	A	*	*	*	*	*
	B	0	2	7	0	0
	C	3	21	15	3	1
How does the quality work go?	A	0	8	8	10	5
	B	0	2	5	2	0
	C	3	24	12	3	1
How well do you understand the quality work?	A	7	10	8	4	2
	B	1	7	1	0	0
	C	13	20	7	1	2
		<b>Yes, totally</b>	<b>Yes, basically</b>	<b>Neither yes nor no</b>	<b>No, not really</b>	<b>No, not at all</b>
Are you participating in the quality work?	A	4	11	9	5	2
	B	3	6	0	0	0
	C	8	21	8	5	1
Are changes and improvements implied effectively?	A	0	5	8	12	6
	B	0	1	4	4	0
	C	1	19	17	3	3

Table 2. Questions and distribution of answers for the employees at companies A, B and C (31, 9 and 43 answered questionnaires, respectively).

Summary of additional comments to the answers in Table 2:

- Company A: The personnel perceive problems with information and routines, little or poor information, and ineffective work routines.
- Company B: The ISO 9000 quality system is not used the right way; maybe it is too complex, but there are no ideas to improve it. The personnel perceive a lack of time to work with the system.
- Company C: The main problem is that the ISO 9000 quality system is not updated. Some think it is hard to find information. Some of the personnel think the improvement work is too slow.

The prototypes developed as a result of the study are presented as follows:

Prototype by Company A

Company A has chosen to visualize the quality system with a tree structure where the list of contents is presented in expandable levels. The actual contents are presented as flowcharts and text documents (Figure 4). Some parts of the flowcharts are linked to other flowcharts or text documents.

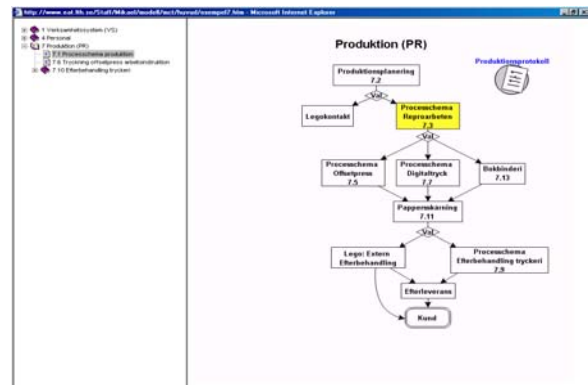


Figure 4. The prototype by Company A based on flowcharts.

### Prototype by Company B

Company B chose to visualize the contents of their quality book with figures and symbols (Figure 5). The figures and symbols serve as links to further information. An intention is to use descriptions such as those used in comics.

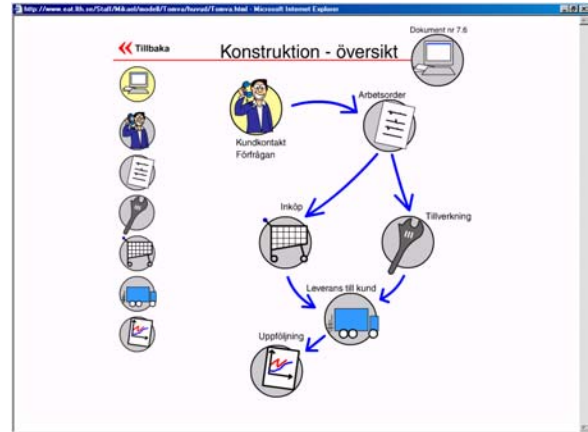


Figure 5. Prototype by Company B based on figures and symbols.

### Prototype by Company C

Company C chose to visualize their quality system based on the plant layout (Figure 6). Different kinds of information can be represented by a symbol or a figure. For example a recycling symbol indicates recycling stations, and a machine indicates one part of the manufacturing process. Further information is presented as text. Administrative routines are connected to the location of the administrative personnel. Different headings link to flowcharts that describe the administrative routines.

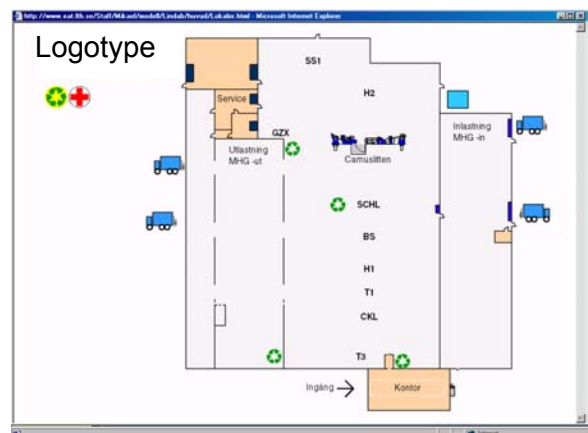


Figure 6. Prototype by Company C based on the plant layout.

A preliminary evaluation and discussion was carried out in each design group based on the result of the study thus far. The prototypes for each company were shown to the design groups. The groups filled in a questionnaire followed by an oral discussion of the result of the study thus far. The following viewpoints and reflections about the prospects of a visualized ISO 9000 quality system were noted:

- Easier and faster to update the system and easy to access.
- Faster to find information, easier to understand and more fun and playful.
- Easier to see what could be changed and improved.
- Faster and suitable for learning, better overview of the flow and where oneself are located. Provide better impressions to customers.

The design group of Company C started with a similar approach as Company A, but it was perceived as too abstract and hard to understand. Company C instead developed a model of the quality system based on the plant layout.

The design group of Company A liked the approach with a plant layout developed by Company C, since it was easier to understand and looked better.

Company B stressed the importance of that the quality system should be more fun and playful and also that it should be easy to recognize the symbols that are used in a visualized quality system. Company B suggested that customers could also use the system in the future.

#### **4. Discussion**

The pilot study revealed the same kind of principles to describe immaterial aspects as the literature research. However, the students of the pilot study used pictures in more detailed descriptions, or combined with text and geometrical symbols, as well.

The company design groups expressed enthusiasm concerning the possibility to enhance their quality systems with visualization. A computer based system could provide an instant update of the routines within the quality system and also provide a more understandable and suitable approach by visualizing the information. The design groups prefer a visualization that contains local symbols that connect the immaterial aspects with the physical environment. They also prefer the use of pictures as much as possible, since this makes the context more understandable. Thus the prototypes developed by the design groups match Approach b of the pilot study. The reason could be that it is difficult to distinguish just what a picture illustrating a scenario (Approach a or c) should reveal in a more applied situation, such as one of the company's processes. But maybe it is a suitable approach to illustrate a single routine.

A developed quality system based on visualization will have better possibilities to engage the personnel in the quality work. The reasons, according to the design groups, is that it will be faster, easier, and more interesting to use than the present system with paper documents, or other text based systems on the intranet.

The methods used in this study seem to work well. Each design group can follow the work of the other design groups via the Internet, and receive inspiration for solutions for their own companies. Thus a collective learning process is enabled via visualization on the Internet. This is of particular interest to small and medium sized enterprises since they, as a network, have better possibilities to develop a visualized quality system.

The participation in the improvement process of the quality system should be continuous and support motivation among the employees (Gontijo and Odenrick, 1999). It is important for the employees to clearly see the relation between their actions and the quality outcome (Pritchard, 1990). Visualization can be an important tool to support these processes. The study will continue to further develop selected parts of the quality system for each company. Interest in the research project seems high according to discussions with other companies and research colleges at seminars and network meetings.

#### **5. Conclusions**

The pilot study revealed different approaches for visualizing the three pairs of immaterial factors communication & information, responsibility & authority, and knowledge & experience. The most common approach was to describe the immaterial factors as relations between different components connected by lines and arrows. The different components were represented by symbols and by geometrical or metaphorical figures, with or without text. Another approach was to visualize the immaterial factors by a scenario in one picture. A third was a combination of these two approaches.

The design groups at the companies consider the use of visualization as a successful approach to enhance their quality systems. They prefer a visualization that contains local symbols that connect the immaterial aspects with the physical environment. The design groups also prefer the use of pictures as much as possible, since this makes the context more understandable. Thus the prototypes developed by the design groups match Approach b of the pilot study. The design groups conclude that a quality system based on visualization will have better possibilities to engage the personnel in the quality work. Such a system will be faster, easier, and more interesting to use than a system with paper documents, or other text based systems on Intranet. Thus such a system will support continuous improvements. The use of design groups connected via the internet is particularly successful for small and medium sized enterprises since they, as a network, have better possibilities to develop a visualized quality system.



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