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QUALITY FUNCTION DEPLOYMENT FOR DESIGNING COLLABORATIVE WORKING ENVIRONMENTS

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This paper presents quality-oriented approach to designing Collaborative Working Environments (CWE) - socio-technical systems, in which technology is mediating human interactions for purposes of group cooperation. Both technical and social aspects of virtual collaboration are characterized by high level of complexity, therefore process of designing CWE's should benefit from approach supporting such complexity. It will be shown, how the Quality Function Deployment method, used for managing the development of complex products, can be utilized into the process of designing such systems.

Keywords: Collaborative Working Environment, E-collaboration, Quality Function Deployment

1. Introduction

Spatially distributed groups use technology for mediating collaborative activities of its members over time and distance. Usage of such technology has influence not only on the quality of the task performance, but also on social and individual aspect of group membership. These social and individual needs impact effectiveness of cooperative processes. Different aspects of the communication in virtual environments are still being researched and designing effective computer-supported environment supporting these issues still remains a challenge [10].

Meeting the challenge of the designing process requires taking into consideration different aspects of collaborative interactions: from both social and technolog-

ical perspectives. However, many aspects of computer-mediated interactions are not sufficiently explained yet, therefore many publications underline issues of lower effectiveness of virtual groups than in face-to-face groups related e.g. to: coordination problems [4], social aspects [11, 13] or information overload [7].

The process of designing Collaborative Working Environments (socio-technical systems, in which technology is mediating human interactions for purposes of group cooperation) is very complex. This paper presents a quality-oriented approach of designing such environments with the usage of the Quality Function Deployment method in order to provide a tool for managing such complex process. Expert's evaluation of the QFD matrix will provide basis for creating a prototype of such environment.

2. Challenges for the designing process

Virtual communication is perceived as a real communication [18], and virtual groups follow the pattern of group development similar to face-to-face groups [13]. As for real groups, also virtual collaborative processes are influenced by the three following areas: task orientation, individual support and group maintenance [1, 3, 12]. These three aspects are necessary for a group to effectively perform common activities.

Problems with supporting these aspects of collaboration have been discussed in literature e.g. in terms of anonymity and disembodiment in communication process [18], group cohesion [8, 11] or performing a task [9]. Some of them result directly from the design approach. Design approach implemented for developing software for supporting group collaboration (groupware) has been described as a "top down" approach - because of its mostly organizational orientation and clear and defined processes between team members. Groupware is described as supporting a defined socio-technical system [16].

The opposite of this approach is a "bottom up" approach of social software (e.g. for social networks), where the decision on how to use it is made by user. However, problems may emerge, because it gives the user multiple possibilities of interaction, but no specific patterns of their usage.

In the meanwhile there can be tendencies seen of incorporating social software into an organizational environment as an extension of groupware functionality and both approaches combine.

Still, multiplicity of existing modules for supporting interactions, their complexity and possible combinations present a challenge in the process of designing Collaborative Working Environments. Therefore, this article presents an approach based on the methodology of designing complex products - Quality Function De-

ployment, which seems to be suitable for the introduced problem and can contribute to the first phases of the software engineering process.

3. Quality Function Deployment method

The process of designing Collaborative Working Environments is complex, which results from the multiple areas that need to be taken into consideration. Collaborative environments are socio-technical systems consisting of multiple interrelated variables and the complexity of correlations results in a need for an evaluation tool that can model defined relations. Tools satisfying such evaluation are provided by Quality Function Deployment method (QFD) and are a subject of this article. Although developed already in the late 1960s (Japan) it is still successfully implemented as a design tool in many organizations and industries [2], also in the area of software design [14].

The focus of Quality Function Deployment with its concept of House of Quality is on creating products basing on customers' needs: their desires and tastes. House of Quality is a graphical extension on top of the QFD approach, providing instruments for interfunctional planning and communications [5]. The basic concept of the House of Quality is presented on Figure 1.

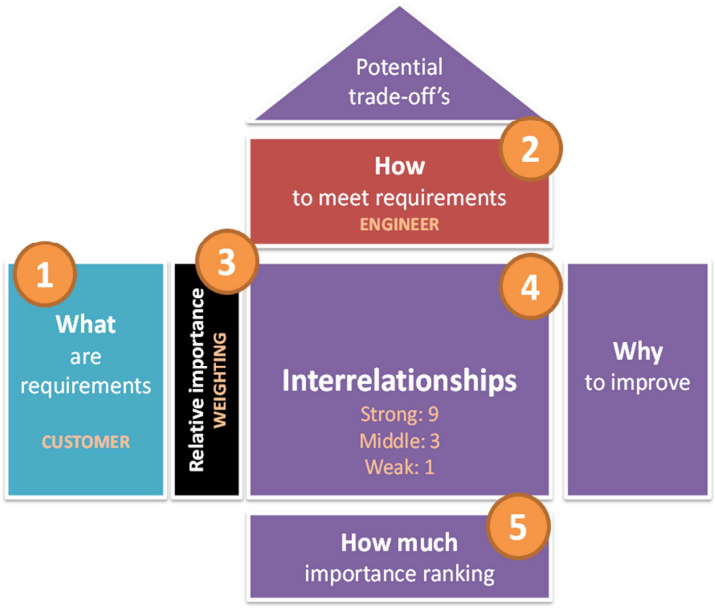

Figure 1. Schematic diagram for House of Quality

The main idea of the Quality Function Deployment method related to the subject of this article consists of the following main steps [5]:

1. Identification of customer attributes (so called *whats*).
2. Identification of the ways of achieving the whats – engineering characteristics (so called *hows*).
3. Identification of the relative importance of customer attributes.
4. Definition of relationships between *whats* and *hows*.
5. Identification of customer evaluation of competitive products.

Customer requirements (1) are identified firstly and often grouped into categories to make the reading of the matrix easy.

The *how to meet requirements* table (2) contains engineering characteristics (EC's) impacting potentially one or more of the customer attributes. If EC does not affect any customer requirement it may be redundant or a requirement is missing. This may potentially lead to expanding the list of customer attributes. A list of attributes may also contain an indication of how engineers influence customer-perceived qualities – e.g. if the direction of influence is positive or negative.

Customer requirements are mostly not equally important - table of relative importance contains weights (3).

The influence of EC's on customer requirements is indicated after defining both *whats* and *hows*. A relationship table (4) defines the strength of the relationships and contains numbers or symbols. The strength of the relationships is mostly defined as weak (weight: 1), middle (weight:3) and strong (weight: 9). Such weighting is not obligatory, depending on agreement other weights can be used as well [6, 17].

If any characteristics that have to be improved simultaneously need to be specified, it can be indicated in the "roof" part of the house. Engineers define a type of relation and take a decision about trade-offs affecting customer benefits.

The *how much* table (5) contains objective measures that enable benchmarking of competitive products. It also informs about importance ranking for engineering characteristics.

Table *why to improve* allows comparing customer's evaluations of competitive products according to the defined customers' attributes.

4. QFD method for designing Collaborative Working Environment

The customer (1) and engineer (2) tables of the QFD are defined as:

1. **Collaboration needs** that constitute *customer* requirements in the QFD approach. Processes of collaborative groups have been widely described in literature and provided basis for defining collaboration needs part of the model.
2. **Collaboration support** that defines *engineering* characteristics part of QFD. For the purpose of design, there have been available features of collaborative software defined in order to link them with collaboration needs in the interrelationships matrix.

The set of customer requirements results from the literature analysis and has been organized into three categories: individual needs (learning, belonging), task needs (production, discussion, problem solving) and group maintenance needs (motivation, trust, cohesion, identification) [1, 3, 12].

The list of Engineering Characteristics has been identified and consists of 34 general *features* of collaborative software (e.g. discussion board, social rating, video-conference, notifications, etc.) [15].

Designing process has been divided into the following phases:

- Initial analysis – required for identification of potential interrelationships between customer requirements and EC's part of the QFD. This phase allowed for the identification of potential requirements or engineering characteristics for which no interrelationships have been defined.
- Expert evaluation of the QFD – required for defining the strength of the interrelationships and the importance ranking of the features for satisfying customer needs.

In the initial analysis phase there has been defined possible existence of the interrelationship between every requirement and EC. The basis for this phase was literature research. Existence of the interrelationship has been marked in the table by an 'x' sign. The strength of the relationship has not been defined due to the fact, that available literature resources didn't allow to draw conclusions about relative importance of analyzed features. The result of this phase was a matrix, where all customer requirements and EC's were matched (Figure 2).

This initial matrix provided first insight into the potential importance of the analyzed features of collaborative software.

	private message/email	bulletin board/newsletter/notes	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference
Individual Needs								
Learning	x	x	x	x	x	x	x	x
Belonging	x		x	x	x	x		
Task Needs								
Production	x	x	x	x	x			
Discussion (asynchr.)	x		x	x		x		
Discussion (synchr.)						x	x	x
Problem solving	x		x			x		
Group Maintenance Needs								
Motivation			x					
Trust	x		x					x
Cohesion			x			x	x	x
Identification		x	x	x	x			

Figure 2. Excerpt from the initial analysis of relationships between needs and functionalities. *Source*: [15]

The second phase of the process was expert evaluation of the interrelationships in QFD. The interviewed experts were members of the leading German research institutes dealing with aspects of technology for supporting collaborative group work with experience in using, designing and developing collaborative software as well as in social and psychological factors of group collaboration from the Fraunhofer-Institut für Angewandte Informationstechnik FIT, Rheinisch-Westfälische Technische Hochschule Aachen, University of Siegen and University of Bonn.

The aim of this phase was to confirm correctness of the initial analysis and to collect information about the strength of the interrelationships defined earlier.

The strength of the relationship was defined using the following scale:

- * – weak relationship (weight: 1)
- ** – middle relationship (weight: 3)
- *** – strong relationship (weight: 9)

It has been found, that all expert's evaluations have been similar to each other with minor differences in assessment, which assured consistency of the results. The answers have been averaged and therefore the table can be considered as a representative experts' opinion on the topic of the requirements-features fit.

	private message/email	bulletin board/newsletter/notes	forum/discussion board	blog	microblog/status updates	chat/instant message	audio conference	video conference
Individual Needs								
Learning	**	*	**	***	**	**	**	**
Belonging	*	*	*	*	*	*		
Task Needs								
Production	*	**	**	**	**	*	*	*
Discussion (asynchr.)	***		***	**	*	*		
Discussion (synchr.)						**	**	***
Problem solving	*		*	*	*	**	*	*
Group Maintenance Needs								
Motivation	*		**	*	*	*	*	
Trust	*		**	*	*	*	*	**
Cohesion		*	**	*	*	*	*	**
Identification		**	**	**	**	*	*	*

Figure 3. Excerpt from the expert evaluation: QFD relationships table and importance ranking. *Source*: [15]

It has been also found that answers are consistent with the table resulting from the initial analysis and therefore it provides ground for validating initial analysis of the collaborative features.

This evaluation allowed for drawing the following conclusions:

- Collaborative group needs cannot be met by a single tool or a pair of features, but require a combination of tools to effectively fulfill all the aspects of group needs.
- There are collaborative features that meet a broad range of group needs (e.g. discussion board) as well as features with very limited potential support for collaborative needs (e.g. web feed).
- Collaborative features found most valuable originate both from social software and groupware systems.
- Social software features were found valuable not only for meeting social needs, but are also perceived as able to support task needs.
- The social networking functionality is not only perceived as a tool for connecting with friends, but also as a tool helpful in generating trust as well as a tool valuable for learning needs: e.g. finding experts or professionals.

The set of features found most valuable by experts contains: discussion board, social rating, wiki, video-conference, private message/email, calendar and chat.

This first analysis provided background for creating a first-stage prototype – a web-based platform that will be a subject for testing the appropriateness of the QFD process.

6. Conclusions

The Quality Function Deployment is an approach for creating products basing on customers' needs. Development of IT systems can benefit from the implementation of the QFD approach, especially in the process of designing complex socio-technical systems. This article presented possible implementation of the QFD method in the process of designing Collaborative Working Environments. The Quality Function Deployment method can be implemented as an extension of the traditional software engineering approach as a decision support tool, however usage of the QFD can be also extended on further phases of the software engineering process [14].

This article presented the process of utilizing QFD method, starting with gathering customer requirements – needs of collaborative groups, defining engineering characteristics – features of collaborative software, then defining interrelations and putting them into QFD matrix. As a result there have been identified key features required to be implemented in Collaborative Working Environment in order to satisfy customer requirements. These features have been identified according to expert's evaluation of the QFD matrix and will be subject for implementation of the prototype of a collaborative system.

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