INFORMATION BEHAVIOR IN MULTIDISCIPLINARY DESIGN TEAMS

Ensici, Ayhan; Badke-Schaub, Petra

ABSTRACT

A common challenge in business life is the need to compose multidisciplinary teams to foster efficiency and innovative thinking by using different expertise on a problem or project. The research area of this study is to analyze information dimensions that occur in multi-disciplinary design teams during their problem solving activity. In order to observe and record multidisciplinary information behavior of design team work, a design task in a laboratory environment has been set up. For in-depth understanding of the process the verbal transcripts have been analyzed and coded according to 'design content' and 'information behavior'. The data describe different information behavior during the design process and show the flow of information within the process. The results gained from the frequency and duration analysis clearly state that using more information or dedicating bigger portion of time to information behavior do not help tphe team to come up with the desired outcome. The results of design content analysis provide a thorough understanding of the information flow based on the design content.

Keywords: Design Teams, Multidisciplinary Information, Design information, Cognitive Process

1 INTRODUCTION

In response to changing market conditions and to the products being more complex, product development face manifold requirements in order to create successful products. A common challenge in business life is the increasing complexity of products and services but also technical, juridical and economic interdependencies. Most of the design tasks exceed individual person's abilities, thus design teams are formed with the consequence that individual cognitive and motivational processes interact with social processes [1]. In larger projects, multiple teams have to work together on different functions/parts of the products what forces the composition of multidisciplinary and often even multi-national teams to fulfill the various requirements from the different stakeholders in the system and to foster efficiency and innovative thinking by using different expertise on a problem or project.

In industry there are usually two ways of composing a team, either according to organizational needs or project based. In general, organization based teams are often more composed as mono-disciplinary team, where team members are selected among the staff of the department while project based teams consist of members chosen from different departments and professions.

Throughout the design process stages, the prevailing task of design teams is the execution of information processing in a multidisciplinary context. Thus different complex information processes are integral part of any design process [2]. The definition of information needs, information search, evaluation and application of multidisciplinary information are of major importance in design team work. Design information is shared and applied by designers has become increasingly vital to the overall success of product design, as needed information is an advantage for efficient design decisions.

While designing, designers do not tend to spend a lot of effort to search information. In the design process the information that is not easily accessible leads designers to take quick decisions which may cause a failure on the final product. Designers usually do not like to search for information in catalogues, in computer-mediated systems, or in information lists because they assume that the search will take too long and because their previous experience has been that such a search often had not elicited relevant information. [3]. This might not always be the accurate and reliable information.

Research [3,4] has shown that designers prefer to search information by asking their colleagues rather than other information sources. Sharing information in design teams occurs easily, but defining, retrieving and applying the appropriate/accurate information often do not happen in the best way.
Overall, research on information behavior focusing on multidisciplinary design teams is rare. This study aims to further explore on the information behavior dimensions that emerge in the conceptual phase of design problem solving and influence the decision making. The primary purposes of this research are twofold:
1) to describe and understand the team design information behavior
2) to investigate the application of multidisciplinary information in achieving design solution.

2 DESIGN TEAMWORK AND INFORMATION

It is widely acknowledged that today's design tasks need to be executed by teams consisting of members from various disciplines. The complexity of design process fosters the need for more descriptive studies of these design activities. Although design problem solving activity is in much the same way within teams and individual designers do, there are fundamental differences. Social aspects of teamwork, like social interaction in the design process play a significant role for the success of collaborative design [5]. Design team members should understand the design problem, generate different alternatives solving it, and different information for evaluation.
As Dasser et al. [6] indicate, collective practices of design have been studied for a long time from multiple viewpoints: organizational analysis, social psycho-social and psychic analysis. However research studies on information with a focus on a multidisciplinary design team are rare.
Communication, collaboration and co-ordination are all constituent dimensions of the co-operative work process [7] that shows the different dimensions required for effective collaborative design. The communication dimension of co-operative work consists of information and knowledge transfer among design team members. Accordingly communication is accepted as the fundamental aspect of support for collaboration in design teams [8] [9]. Comprehensive studies have been done on design team thinking process by analyzing communicative acts of design teams [10].
Design problems are characterized as situations, where a lot of information is needed, there is often very little information about the problem, even less information about the goal (solution) and no information about the transformation function [11]. Design problem structuring can be seen as a process of retrieval of needed information and using it to define the design problem space. Poltrock (2003) describes the term of 'collaboration information retrieval' as involving identifying an information need, formulating a query, retrieving information, evaluating it and applying it to address the need and communicating about the information need, sharing the retrieved information within the team, and coordinating the constituent information retrieval activities across multiple participants.
Contemporary product design requires much heterogeneous information during the process. Searching, managing, sharing and usage of multidisciplinary information get major importance in design team work. One major problem, faced by many organizations is identifying what knowledge and information to capture, and once identified, what levels or extents of capture are required in order that the information or knowledge is truly useful [12]. The effective utilization and usage of information would support the decision-making processes adding to the richness of successful design solutions. Many design researchers strive to identify information needs in engineering design [2] [13] [14]. Research by Olson et al. [15] emphasized the importance of information sharing in collaborating design teams by focusing design meetings.
Cartensen [16] emphasizes that the efficiency and the quality of the design process depends considerably on how well designers are able to handle large amounts of information. The way how and when information is shared and used by designers has become increasingly vital to the overall success of product design. Communication between colleagues is extremely important for the exchange of decisive design information [3].
During the design of a product many decisions are based on incomplete data and individual assumptions, leading in many cases to design decisions being sub-optimal; the engineering designer not being able to

transfer the most appropriate information to the product (Court et al. 1995). In multidisciplinary design works information exchange refers to the reciprocal interchange of information between design team members from different disciplines. If team members fail to exchange information, they will be preoccupied with the features of the design problem most salient from their particular discipline's perspective and have a restricted view of feasible solutions [17].

3 RESEARCH APPROACH

In order to observe and record multidisciplinary information behavior of design team work, a group design task in a laboratory environment has been set up. Contrary to usual laboratory research this experiment is a combination of a controlled setting on the one hand, which enables the researcher to reduce the influence of context variables that cannot be controlled in a real life setting and allows replications of the study and the manipulation of a different set of variables. The design teams' working processes were recorded, transcribed and then categorized. Using a group rather than an individual meant that verbal articulations could be obtained more easily than through thinking-aloud protocols in an individual laboratory setting.

3.1 Experimental Case Studies

Two design teams were analyzed, each consisting of three professional experts, from different disciplines, working in the same company. Participants were selected with a comparable background and experience of professional life.

The design task has been selected considering that it should be able to finish the design in a limited amount of time. After a briefing about the experimental set-up of the study, participants were handed the assignment individually. Before the experiment, participants were given an elaborated questionnaire about their thoughts on the design task. The design team had been recorded with video cameras in a design studios at Istanbul Technical University and various basic drawing materials were provided in the studio. The assignment was to design a portable brazier (barbecue) specific for the Turkish market that can be used at outdoor during picnic attractions in recreational green areas. The general frame of the design task is stated as follows:

> *"Design a portable brazier (barbecue) specific for the local market that can be used at outdoor during picnic attractions in recreational green areas. The company which has considerable experience in producing products for domestic and international markets now would like to enter to the local small kitchen product market with a new brand. The company wants differentiation from other products in the market with design, innovation, quality and price in order to ensure a prestigious penetration to the market."*

3.2 Data Collection

In this study, primarily protocol analysis was used as method for analyzing the information behavior of design teams. As well as protocol analysis method, interview and document analysis were also used for the data collection.

Among other methods of data analysis, protocol analysis is accepted as the most efficient approach to gain insight into human cognitive processes and it has been widely used for investigating the cognitive processes of individuals as well as teams [10] [18] [19]. By applying Protocol Analysis Method one can consider the verbal records from which mental processes are derived. Teamwork situations are thus especially helpful as every verbal utterance presents the own mental model which between members is a separate communication message. Thus every message is part of information sharing towards developing design as the goal of the task. Designers in a team talk about different issues, develop more than one explanation, relate to different contexts, often even in one utterance. In our analysis each utterance may consist of one, two or more meaningful segments. We define each meaningful piece of expression as a cognitive action.

3.3 Data Anaylsis

Primarily for the analysis of data obtained from the records, they are transcribed. In analysis of transcribed data every package of message including a cognitive action or reasoning accepted as segmented part of protocol. Mostly recognizing the segments including design knowledge, design reasoning or a cognitive action in design process is easy for a design expert. Besides recognizing segments, reasons have to be considered in such a sociological process.

One of the most critical steps using protocol analysis is the development of a coding system. The categories of a coding system should be theoretically consistent and exhaustive to ensure that each expression can be assigned to one category. In this research the coding schemes were developed; (a) information behavior and (b) design content. Latter one used to explore the whole design process and to be able to code information behavior activities more precisely. Information behavior categories formulated based on previous empirical studies, on theoretical models in cognitive psychology and on design methodology, and then tested and further refined based on data from the experiment.

Documents produced by the design team during the design process have been utilized to detect the design issues the team discussed. Design content is different from design issues due to design issues are specific topics related to given design task. Design teams continuously discussed issues coming from design ideas, problems or solutions that whey developed in problem solving process. Those issues could be discussed in the context of one content, or as mostly happened, they were discussed in the context of multiple design contents.

4 RESULTS

At the end of the allocated time of the experiment the Design Team 1 was successful and finished with a mature product proposal, whereas Team 2 could not reach the required result.

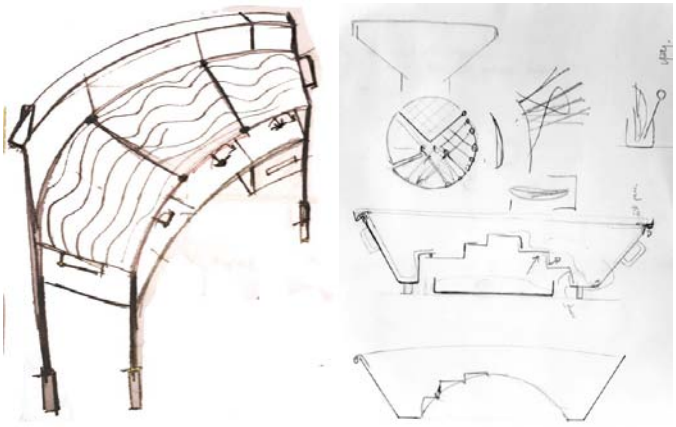

Figure 1: (a) Final drawing of Team 1 (b) Final drawing of Team 2

The first team focused on designing a barbecue with circular curved shape to give cooker a central position and let him to control all stuff easily. The barbecue consisted of 3 similar parts as co-expandable according to the number of users (Figure 1a).

Team 2 concentrated their solution concept on the development of a design which they called “business card barbecue”. Their design solution was basically aimed to have simple installation and being portable. According to the team the first two most important features of their barbecue is that the upper part can be used as a serving tray and prevent oil from flowing into the fire (Figure 1b).

In this paper the conceptual design phases of the design processes have been analyzed in detail for the preliminary results of the experimental studies. Experimental research is configured as multi-stage. Right after giving the design task, the design teams began work on the design problem. This stage of the process, where a conceptual analysis of the problem is being carried out by design teams, was found to be more intensive in terms of use of information.

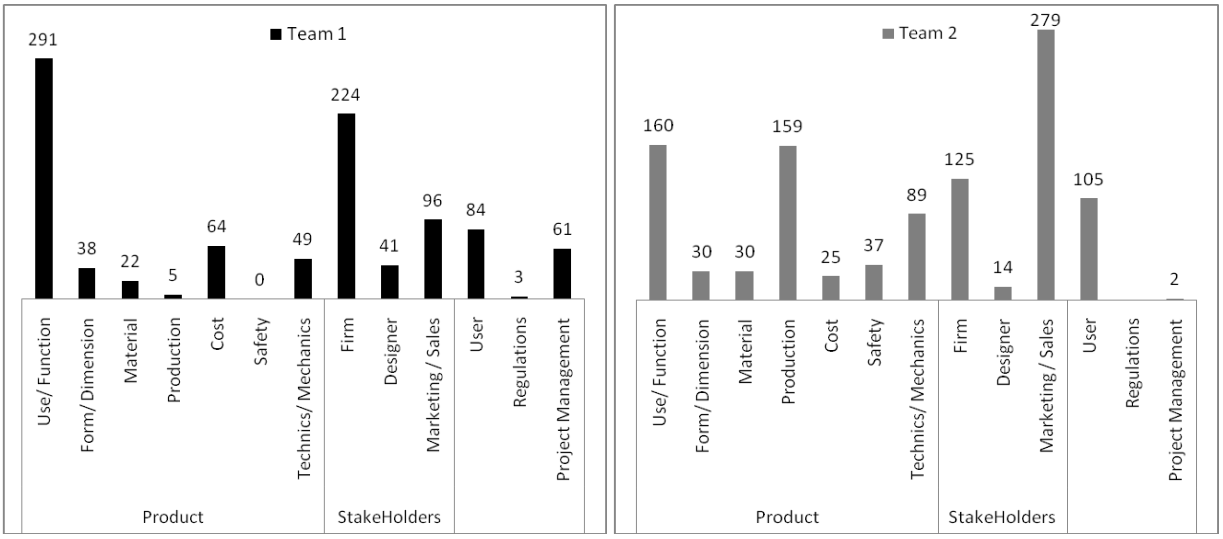

Figure 2. Duration of Information exchange of design contents

For in-depth understanding of the process the verbal transcripts are analyzed and coded according to Design Content categories. This analysis is also used to define the flow of information within the process (Section 4.2). The first team spent most of their time dealing with functional issues as a response for finding particular ideas for a local product whereas marketing issues were the main subject of team 2 (Figure 2).

4.1 Information behavior in multidisciplinary design teams

The objective of this research is to explore the design process to put forward the information behavior flow particularly in the initial stages of the multidisciplinary design team works. Studies on information involves researches of different areas, mostly done on individuals and information behavior domain basically covers defining information needs, information seeking, and using information [20] [21]. It can be stated that in general 'Information Behavior' involves the generation, acquisition, use and communication of information [22]. Further to these concepts to capture information behavior in design needs to define certain activities. Baya [23] in his doctoral research, introduces 'Information handling and design information framework' in which he suggests *Generate, Access, Analyze* as informational activities.

Information behavior refers to all activities and subtasks undertaken by the designer that involve information seeking and sharing in product design teams [1]. The activities of information acquisition, organization, sharing and applying are all related to the efficient design output. In this study 'information' refers to all types of multidisciplinary information including data and knowledge in the domains of such as engineering, manufacturing, marketing, human factors etc. that designers share and apply in achieving desired solution.

Defining, Searching and Application of Information

As for the focus point of this study to represent information behavior flow in team design process we structured an information behavior with five categories (Table 1).

Table 1. *Information Behavior in Design Teams*

Information Need	Defining (D)	Identifying information requirements
Information Seeking	Searching (S)	Asking information for related issue
	Generating (G)	Representing and sharing information
Information Applying	Elaborating (E)	Structuring and formulating information for design task
	Evaluating (V)	Reviewing and Inferring information

A coding scheme was developed to assess the different kinds of information behavior in multidisciplinary teams. During the design process the required information can be reached by asking questions and the existing information gap can be filled by any team member but also by all kinds of different sources such as Internet, etc. Once information has been generated, it must be elaborated by structuring and prioritizing the information in the context of the design problem. In some cases, information elaboration comes from the statements that team members produce based on their knowledge. Finally generated and elaborated information in the process is evaluated or needs to be evaluated by team members to be able to decide about the value of the information for the decision.

The first team has executed information behavior in one third of the time during the conceptual design phase whereas the second team, which is couldn't come up to the end of the process with a embodied design solution, have used nearly half of the time (Figure 4)

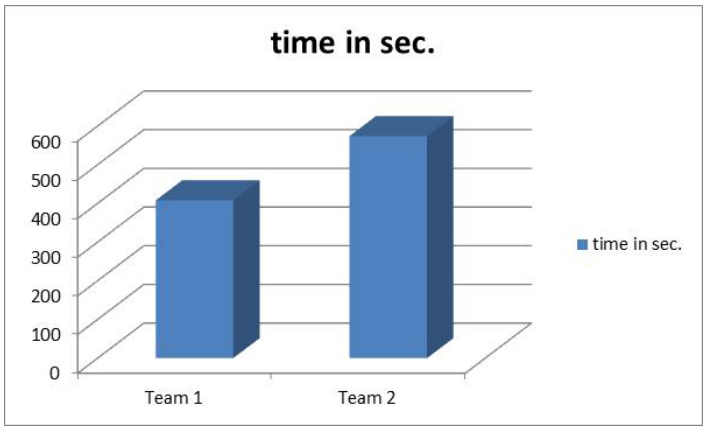

Figure 3: Time allocated to information processing in both teams

The most striking results can be stated comparing the activities 'information searching' and 'information elaborating' (see Figure 5). Team 1 has dedicated to 'information searching' almost three times the duration compared to team 2. For the category 'information elaboration' almost the opposite can be stated. Information elaboration has been the most time allocated by team 2 and this was 3.5 times more than team 1 allocated.

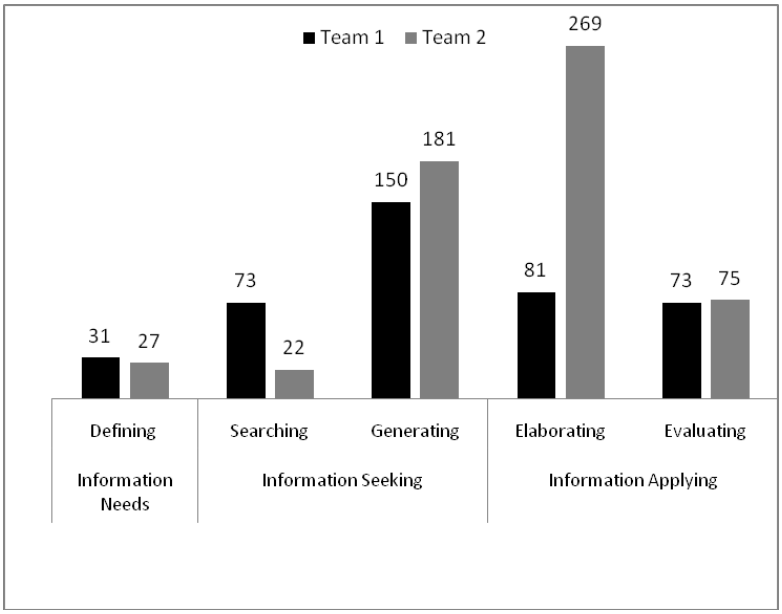

Figure 4. Duration of different categories of information behavior

This result - although only found here in an exploratory study including two multidisciplinary teams – is interesting. Comparable teams trying to solve the same design problem under the same circumstances, show very different information behavior. Looking at the results of frequency analysis of the information behavior, the results of both teams is parallel, while duration distribution rates demonstrate some different results.

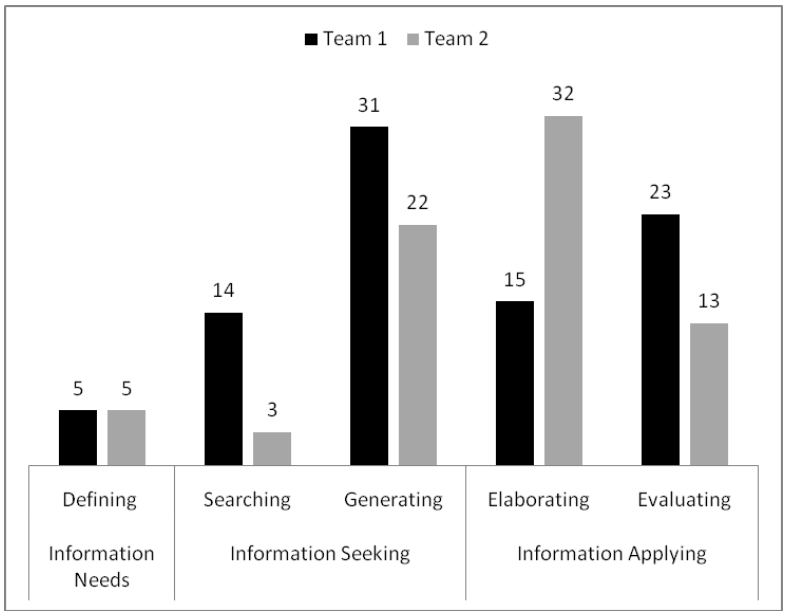

Figure 5. Frequencies of Information Behavior

In the analyzed phase of the design process 88 units of information behavior has been recorded for team 1 against 76 information units of team 2. Defining information needs has been the least frequent behavior of both teams. The most frequent information processing activity of team 1 was found in information seeking. information behavior by team1 was 'generating', while team 2 mainly elaborated information. Team 2 devoted of an average of 8 seconds for every 'information search', 'generating'and 'elaboration' behavior, conversely Team 1 used an average of 5 seconds for the same information behavior categories.
Despite the greater use of time for the information generation, team 2 brought out less "information generating" units than those produced by team 1.
The results gained from the frequency and duration analysis clearly state that using more information or dedicating bigger portion of time to information behavior do not help us to come up with the desired end.

4.2 Information content in the design process

Analyzing the design content, it is obvious that the content is problem dependent, and thus varies with the design problem whether it is more or less technical, etc. However, the results have been presented that even when comparable teams solve the same design problem under the same working conditions, they could exhibit different information behavior. Although individual prerequisites [10] have great impact on solution strategies of teams, common behavior mechanisms should be considered. The main result of design content analysis can be said as that team 1 was *firm* and *cost* oriented and team 2 was *marketing* and *production* oriented.
Comparing the two multidisciplinary design teams, the successful team 1 showed a higher number of information behavior. Team 1 used one of the information behavior for 88 times in 10 different design contents (Table 2). Team 1 has produced the majority of information behavior in the context of *Firm* related topics. *Firm* related information content was mainly provided by one Marketing Department expert

who has serious objections about the firm's strategies. The expert, by generating and evaluating related information, provided the group with the necessary information to be able to discuss on the issue. *Cost* was their second major content of information behavior.

Table 2. *Information behavior related to the design content:* ***Team 1***

P Management	S
Function/Use	G GSG SG GG
User	E GESGGE EGVGE
Form	SS SS
Marketing	E V EGEGE S GE
Firm	DGEDDSES G EGEV EVG GG VVG EG DS GVE
Cost	GESVVDGVVVV VVGVG V V
Material	VGGV
Technical	S G
Regulations	G

As we stated before, although team 2 used much more time for information processing activities team 1 in sum showed less information behavior, that was 76 incidents of information behavior. At the end of the process they were still in an unresolved situation. Their major information topics were *marketing* and *production.* Team 2 employed 43 information behavior of the total.

The reason of the information topic was clearly because of the individual professional origins of the team members. The marketing and production based two members both raised the information sharing and exchange unnecessarily in team work. They have *elaborated* many information which didn't find a reflection in the final design. The designer in the team took almost no role in information activities which would have been necessary as the information activities were important for applying information to the product.

Table 3. *Information behavior related to the design content:* ***Team 2***

Safety	G
Function	E DEG G
User	GEE EEEE GE E V
Marketing	EVGEG E S EGEV DG D S V SEGEG EE G DD E EE
Firm	V V VV E E EGV
Cost	E
Material	G G E E G
Technical	E G
Production	GEG GEV EG G VV GEV

5. CONCLUSION

Through this study we attempt to explore and analyze information behavior in multidisciplinary design teams. The paper outlines the analysis of information behavior to gain a better understanding of information activities in multidisciplinary design teams and the relationship between information and design solution. Preliminary results indicate differences in duration and frequencies of information behavior of comparable teams working on the same design problem.

We executed two experimental case studies by capturing different information processes such as definition, generation and application of information. And although sharedness of information is a major requirement for multidisciplinary teamwork, there is more about the information behavior than pure information exchange. Multidisciplinary teams can easily share information however the application of the information does not always occur.

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