INTERNATIONAL DESIGN CONFERENCE - DESIGN 2004
Dubrovnik, May 18 - 21, 2004.

DESIGN 2004

DEVELOPING DECISION COMPONENTS MODEL FOR ANALYSING DESIGN DECISIONS IN MONO-DISCIPLINE DESIGN TEAMS

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Keywords: protocol analysis, coding scheme, design decision, design teams

1. Introduction

Nowadays, design tasks are more difficult and complex processes. The solution for this complex problem structures need design groups rather than individuals. “How does a designer design?” is a key research topic in design methodologies after 1960s. Recently, the question “How do designers design together?” gains more interest.
By defining the factors to be considered in the development of multi discipliner design teams, studying how a mono discipline design team works will form the basic experience.
In this research, it is aimed to analyze and determine the components of decisions taken in design teams. The study of design teams by analyzing design problems, with the relation of decisions taken in this process, provides the cognitive process of design team practice to be investigated. In this research, the structural characteristics of design decisions taken in design teams will be studied by using record analysis method. The *decision components coding schema*, which will be used by determining design decisions, will be formed. This study has two goals;

1. Determining enough decision components for obtaining design decision analysis and developing *decision components coding schema*.
2. Analyzing design process and design decisions in design teams by defining decision components.

2. Design Team Research

The number of studies about protocol analysis and teamwork in design methodology literature are increasing everyday. The first planned study about design teams was presented in ICED in 1993 with the theme “teamwork”.
Tang and Leifer’s (1988) study about research design methodology can be counted as one of the first works about in design teams. In that study, some experimental studies with mono-disciplined design teams had been made in order to understand the actions of design teams in their environment.
In 1994, Delft University had organized a workshop, called “The Delft Protocols Workshop” and which was about record analysis method. This workshop was important for design methodology in two ways. First, record analysis was used systematically and planned in a design study for the first time. The same records were given to twenty design researchers and their analysis was made. The second important aspect is that for the first time team and design subjects are studied systematically.
Ullman and others (1996) studied the development of product information and decision making process in design teamwork. They formed a decision making model with subject, criteria, alternative, discussion and decision titles in order to determine decision making processes.

Valkenburg (2000) studied on reflected practice in design teams. Beside the records used in Delft Workshop, he also studied record of a second team which was also based on a research done in Delft Workshop.
Gero and Neill (1998) have developed a methodology that uses protocol analysis to investigate the process of designing. They applied a coding scheme which they developed depends on micro and macro strategies.

3. Decision

Rapid change and globalization require the firms to make many successful design decisions. The complex structure of the products has on the one hand led to an increase in the number of such decisions and on the other hand made these decisions more difficult than ever. Theoretical work done on decision making patterns and processes has become the foundation for the design decisions coding schemas that are developed in this work. The most well known and accepted model is the three-tiered definition developed by Simon .

1. Intelligence: Problem analysis, determination of objectives.
2. Design: Finding, developing, analyzing the options
3. Choice: Choosing a solution.

The common aspect of many defines about decision that it is a "process" and the act of "choosing among alternatives". Designers choose among a set of alternatives that have emerged from their objectives. From the aspect of the designer's cognitive performance (actions), the design process can be defined as process that involves, in its most general meaning, repeated acts of problem solving and decision making. Problem solving and decision making stages proceed simultaneously within the design process. "Researches show that most of the time decisions arise during the process of problem solving**"** (Belecheanu et al. 2002).

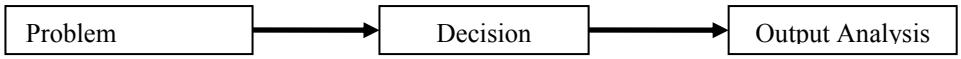


Figure 1. Problem solving process (Belecheanu and others, 2002)

These models and explanations are sufficient to clarify the decision making process. However, when there is a need, as in the inside-team design decisions, to examine the design decisions in detail, then it is necessary to put forward the components in a complete manner and in a detailed fashion. "Group decision making models show that decision making contains the stages of definition, development, choosing and realization" (Pugh, 1996). Bayazıt (1994) has observed that in a decision making problem there are at most eight components.

1. *Decision makers*
2. *Objectives*
3. *Decision criteria*
4. *Constraints*
5. *Alternatives*
6. *Events*
7. *Result*
8. *The method to be followed in decision making, decision making process*

In designing, decision making occurs in a social influence environment and in an organizational framework. The number of members in teams, the possibility that there are similarities or differences in the disciplines they work in (homogenous or heterogeneous), their experiences, age, skills, statutes (positions), their respective contribution to the problem solving all shape the structure of the group's decision. The elements of these decision structures can be in a state of three-poled interaction that is defined in the Group Interaction Process Analysis model of Bales.

4. Research Method

The controllability of the environment in an empirical research makes possible the comparability of the results, thus it is the preferred method in this research. The experimental environments built-up in

design researches are identified between artificial laboratory experiments and unrestricted behaviors. (Mazijoglou and Scrivener, 1998).
The conceptual design phase has been chosen as the main consideration in this research. The personal knowledge and experience of the designer are considered adequate for the conceptual decisions taken by the designer in the concept development phase. The fact that the concept development phase is richer in terms of density of the design decisions is the reason for its consideration as a research field.
The protocol analysis method has been selected for the identification (detection) and the analysis of the structural elements of design decisions taken in design teams.

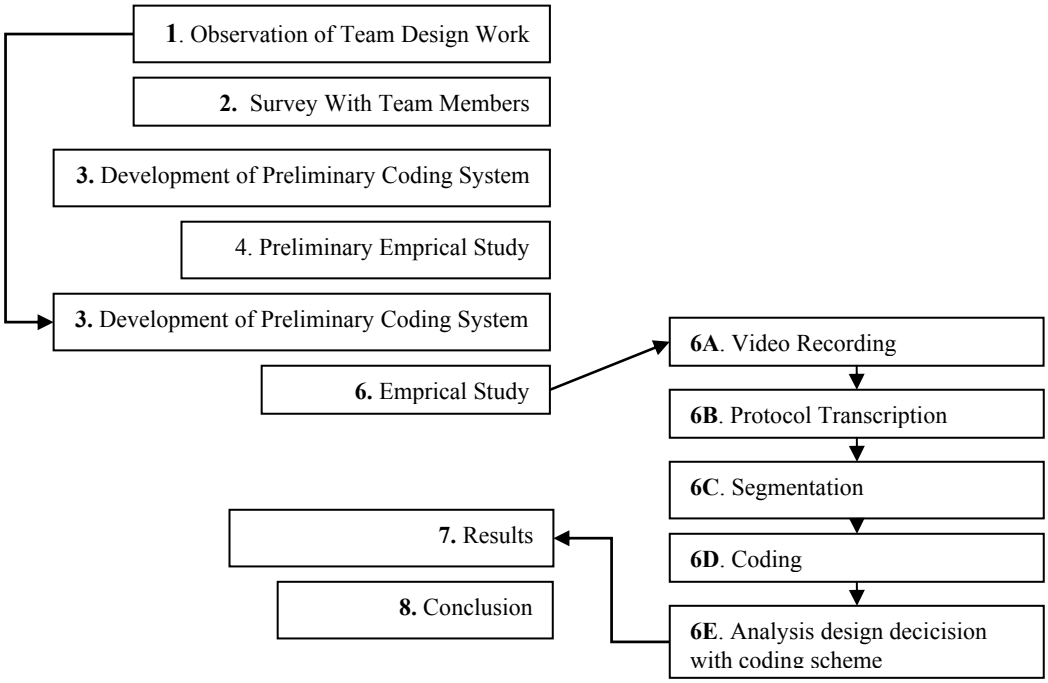


Figure 2. Research Method

4.1 Preliminary Empirical Study

The preliminary empirical study constitutes the first of the two phases of design execution practices realized with the team members. The design brief of *The Porada International Design Award 2002 Furniture for Children competition* was given as the design task.

4.2 Empirical Study

The empirical study constitutes the research's basic phase. The same design team participated in the experimental execution practice. The execution method of the empirical study were developed using the results and findings of the preliminary empirical study. The empirical study phase has been confined, unlike the preliminary study. In this phase, the design brief of the *3rd Leitz Innovation and Design Award competition* has been given as the design task. The brief was narrowed down and the task was identified as "a table top product which will serve as an organizer for paper piles and used papers."

5. Protocol Analysis

In this study a coding scheme is developed in the protocol analysis method, to determine the design decision components. In protocol analysis method, while subjects are observed, to analyze their cognitive process it is ask for to utter all of their thoughts, and think-aloud. In team works there is not necessity to think aloud. Findings gathered from preliminary research support this sight. Because of the structure and format of the team work, it is a must to generate verbal expressions. The need of

communicating with each other in the team formed the natural reflections of cognitive processes and that becomes recorded data's. These data's describe the ideas of every individual in the team work. In the segmentation process, if verbal and graphic expressions are not clear enough, the notes of the experiment propellants have been used for deciding. In some cases behaviors complete meanings of the expressions in design process. 2 video cameras are used in the research for general recordings and close ups, facial expressions and attitudes are also evaluated as protocol segments.

5.1 Transcription

The empirical research finalized with transcriptions of 100 minutes of recording which is approximately 5900 lines. Every line shows one minute. Documentation system consists of three columns for recording every data which worth coding, for recording and organizing data's for interpreting the segments thorough transcription.

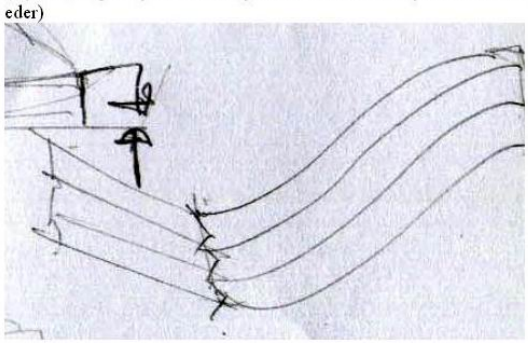
Time	Drawing	Protocol
01:04:01	(Üye Ö, diğer üyelerin konuşmasına katılmadan çizime devam eder) 	A: That inclined things don't telescope.
01:04:02		
01:04:03		
01:04:04		H: Yeah it is right
01:04:05		
01:04:06		
01:04:07		
01:04:08		
01:04:09		
01:04:10		
01:04:11		
01:04:12		
01:04:13		
01:04:14		
01:04:15		A: Do we recognize this form from elsewhere?
01:04:16		
01:04:17		Ö: From where?
01:04:18		A: There is one like this in someone's room.
01:04:19		

Figure 3. Transcription

"Transcriptions which are transformed to texts do not provide enough information about interaction between the team members" (Valkenburg, 1998). Sizes of sketches in the second column show their real time period according to the lines in the first column as they have been draw and used. Also in the verbal phase the sentences have been showed as their durations according to the time lines in the first column.

First column displays time as seconds and second column shows the sketches of designers that they are using at the moment. In the third column verbal protocols of the designers take place. Verbal expressions of designers also can be seen in the tables. The capital letters symbolize the active (speaking) designer

5.2 Segmentation

Krech at al. **(1962)** define segmentation unit as "the smallest division of verbal and non-verbal behaviors that can be distinguished". In this paper segments has been accepted one a unit. In design teams every expression is a message. Every expression can define a step, cognitive activity or judgment in the design process. Every message/expression is an indicator of the research steps that define the development and finalization. Valkenburg (2000) talks about three segmentation method;

1. *Segmentation without interpreting,*
2. *Segmentation with interpreting,*
3. *Segmentation with interpreting in the context of a theory,*

Third segmentation method generally applied in this research, but also second and first segmentation methods are partially applied. In the first phase of the research all the sentences accepted as separate expressions. This approach is compatible with the second method of Valkenburg. The focus of attraction of expression holder changes according to the personal cognitive processes in time. This

defines two or more different units in the expression. The definition of different parts has been done during the coding. This approach is compatible with Valkenburg's third method according to the pre-set categories and defined phases. Every individual expression accepted as –at least one- describable unit, which is compatible with Valkenburg's first method of the segmentation. Some of the verbal expressions do not have meaningful totality, in these situations sketches, drawings and body movements that supports the expression determined as a unit.

e	Protocol	O	Ka	Kg	Pd	As	Aa	Ae	Ar	Cs	Ce	Ca	CoS	CoE	Cd	S	Ss	Se	Sa	D
01:01:21															H					
01:01:22																				
01:01:23	**H**: I am thinking something but… It passes through a shared point, that means it doesn't have to be so big….																			
01:01:24																				
01:01:25																				
01:01:26																				
01:01:27																				
01:01:28																				
01:01:29																	H			
01:01:30																				
01:01:31																				
01:01:32	It can be like that																			
01:01:33																				
01:01:34																				
01:01:35																				

Figure 4. Segmentation in Decision Coding System

Goal:	**Constrain**
Goal (G)	Constrain Suggestion (CoS)
Knowledge:	Constrain Evaluation (CoE)
Knowledge asking (Ka)	**Process**
Knowledge Generation (Kg)	Concept Development (Cd)
Problem:	Synthesis (S)
Problem Definition (Pt)	**Solution**
Alternative	Solution Suggestion (Ss)
Alternative Suggestion (As)	Solution Evaluation. (Se)
Alternative Asking(Aa)	Solution Reasoning (Sr)
Alternative Evaluation (Ae)	**Decision:**
Alternative Reasoning (Ar)	Decision (D)
Criterion	
Criterion Suggestion (Cs)	
Criterion Evaluation (Ce)	
Criterion Asking (Ca)	

Figure 5. Decision Components Coding Categories

5.3 Coding Scheme

In this study two staged method has been conducted while coding protocol.

1. Stage: In respect of literature and according to the data gathered from the studies that has been executed on team design works earlier a coding scheme is foreseen.

2. Stage: Coding scheme which has been foreseen is reviewed by depending to the remarks from preliminary empirical study.

It is accepted that, it is sufficient to evaluate collective output of the team to determine the structural components. The design decisions in the team design process can be recognized by the members separate verbal expressions.

5.4 Decision Components Coding Scheme

According to the aim of the research, an overall decision making coding system is developed for determining structural characteristic of decisions in design teams and defining all actions that will end with a possible decision. An overall category system developed after considering the other researchers' ascertainments about decision and decision making. Design Decisions Coding system

consists of 19 categories that developed by nine main titles: A coding system is developed for determining structural components of design decisions and analyzing its relations with other structures.

In the decision coding scheme, every decision that formed in the process described with different colors. Furthermore, the initials of the team members' name used in the colored bars are for following up the active member.

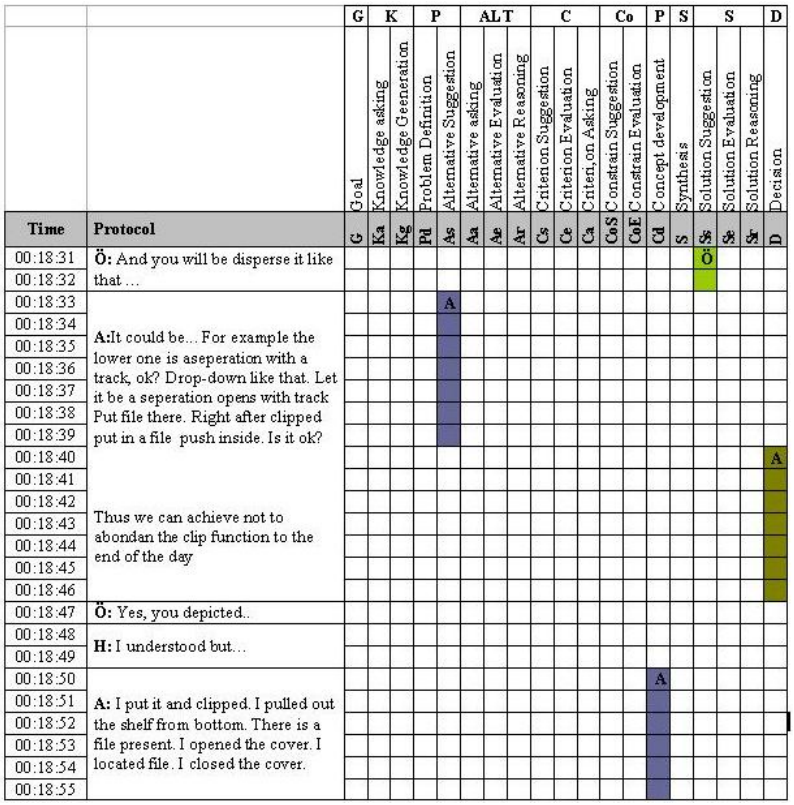


Figure 6. Decision coding scheme

6. Conclusion

By coding the protocol, which has been lasted 1 hour 40 minute, it is possible to get results from discrete points. It is possible to make analysis of numbers of attitudes and components that constitute decisions of members in design activity, also is a social process, within teams. By converting numerical data to the graphics, movements in processes can be traced. As a result of study 758 segmentation/unit has been defined. In the design process 21 decision subject is detected under 6 topics. Total 73 decisions are made in the whole design process. Together with these results, diverse numerical results are gathered;

- Decision subjects and subject duration,
- Decision number,
- Decision components frequency distribution,
- Decision components' duration,
- Dispersion components dispersion between members,
- Decision components' graphics in process
- Decision components' number,

These and similar results can be acquire with ease.

Table 1. Decision Subjects, numbers, average time

Context	Decision Topic	Decision Number	Average Decision Time (Second)
CONCEPT	'Scanner' concept	1	333
	Perfarator and Stampler together	4	78
	Ccordion form and system	10	43.4
	Paper fixer	2	55.5
	Fun concept	1	30
	Track system	1	27
	'Layer by net' concept	-	-
	'2 Sectioned' product	4	44.25
FORM	'Flower formed! product	2	94.5
	Form search	7	31.4
DETAIL	Paper input	-	-
	Layer Deployment system	5	47.4
	'Stoper' between layers	4	17.5
	Grip	5	24.4
FUNCTION	Puching function	18	57.2
	Perfarotor on one layer	1	44
USE	Paper placing format	2	95
	Stowing	1	76
	Layer number	1	25
HOLISTIC APPROACH	General solution search	5	94.6
	Solution of the system between	-	-

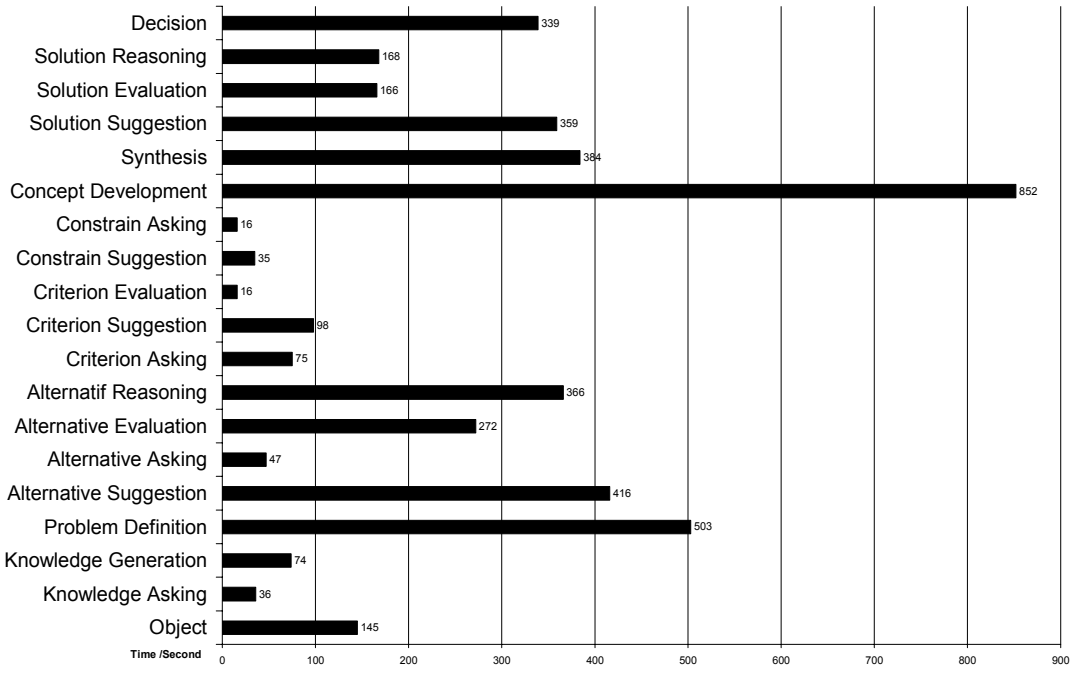


Figure 7. Decision Components Duration

All of these numerical data can be determine every single decision subject.

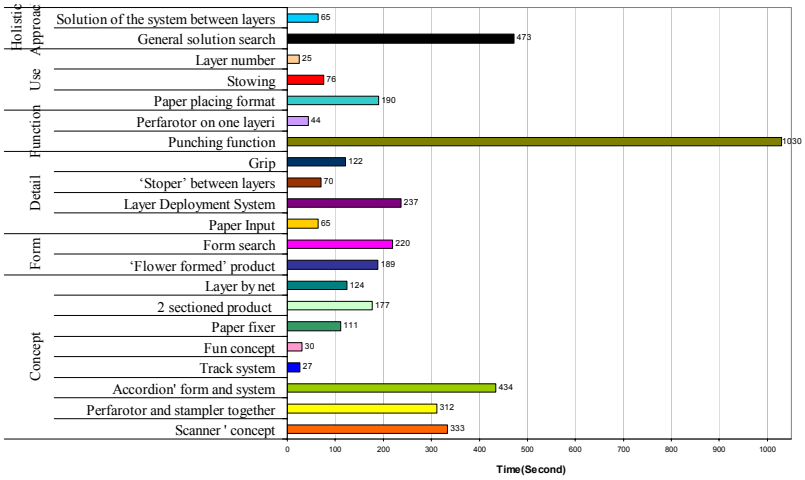


Figure 8. Decision subjects durations

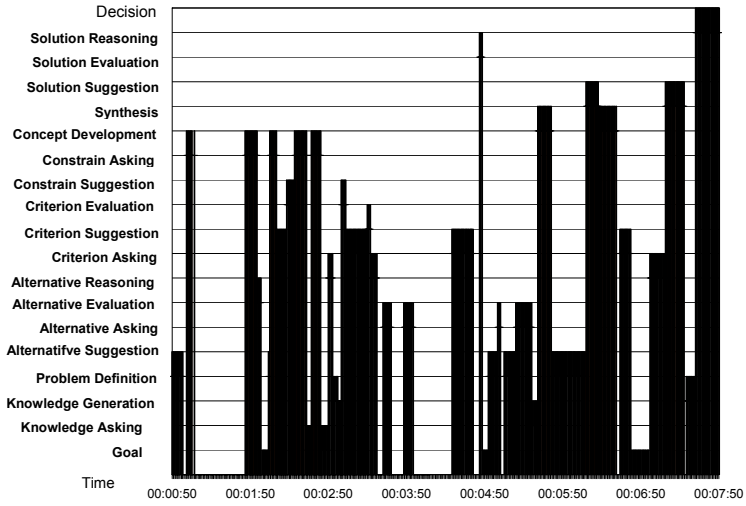


Figure 9. 'Scanner' topic decision components

References

Tang J. C., Leifer L. J., "A framework. For understanding the workspace activity of design teams" CSCW1988
Valkenburg,R.C.,"The reflective practice in product design team" Delft University of Technology, 2000,
Ullman, D. G., Herling, D., Sinton, A., "Analysis of protocol data to identify product information evolution and decision making process" Analysing Design Activity , John Wiley, 1996. pp. 169-185
Gero S.J., Mc Neill t. "An aproach to the analysis of design protocols"Design Studies, Vol. 19, 1998, 21-61.
Pugh, S.,"Creating İnnovative Products Using Total Design"Addison-Wesley Publishing, Massachusetts,1996.
Bayazıt, N., Endüstri ürünlerinde ve mimarlıkta tasarlama metodlarına giriş" Literatür, İstanbu,l1994
Maijoglou, M., Scrivener S.,"The rich picture of design activity"Automation in Construction, Vol. 7,1998, 157-175.

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