On the use of functional and interactional approaches for the analysis of technical review meetings

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Abstract

The object of this paper is to propose and illustrate two complementary approaches to analyse team design activities: a functional and an interactional approach. The functional approach examines how collective design proceeds from the viewpoint of actions and objects. The analyses conducted under the interactional approach concern argumentation and participant roles (and their interaction). Both of these approaches are illustrated by a study of technical review meetings of a software development project. Implications of our results for tools are discussed.

Keyword

POP-I.A. Group Dynamics

Objectives and theoretical framework

The object of this paper is to propose and illustrate two complementary approaches to analyse team design activities, a functional and an interactional approach.

A preliminary remark concerns the fact that our analysis of teams does not take as units of analysis these teams (Wærn, 1998). Our units of analysis are individuals as they work as team members in a meeting.

Our theoretical basis is cognitive psychology and its contributions for analysing the cognitive activities implemented in design, mostly individual, but also collective cognitive activities. The theoretical approach inside cognitive psychology that we follow is the information-processing approach proposed by Newell and Simon (1972), specialised for design problem solving (Falzon et al., 1990).

The disciplines from which concepts are imported are mainly, (1) for the functional approach, linguistics in order to identify and analyse verbal exchanges (dialogs), (2) for the interactional approach, linguistic pragmatics and philosophy (rhetoric) in order to identify and analyse argumentative activities, and social psychology in order to identify and analyse different participant contributions to a verbal exchange according to the participant's role.

The functional and interactional approach

We propose two complementary approaches to collective activities, a **functional** and an **interactional approach**.

The functional approach

The functional approach examines how collective design proceeds:

- from the viewpoint of actions: especially, the classical design problem-solving activities of solution elaboration and solution evaluation, but also specific collective activities such as cognitive synchronisation and conflict resolution;
- from the viewpoint of objects involved in these actions: problem specifications, evaluation criteria, design solutions (which may have the status of solution proposals or of alternative solutions).

This type of analysis leads to results such as those presented in previous studies, for individual design (Détienne, 1998; Falzon et al., 1990; Visser, 1991), or for collective design (Falzon, 1994; Falzon et al., 1996; Herbsleb et al., 1995; Visser, 1993). In particular, it shows the actual functional activities of a team as compared to the prescribed task. Knowledge of the resulting deviations is necessary from a viewpoint of cognitive ergonomics, as it is to understand the objectives of the team and the nature of their actual functional activities implemented for this aim. This analysis has implications for specifying the nature of the activities to be supported by CSCW and other types of tools.

We are aware that researchers grounding their research in "situated cognition" and "activity theory" adopt an antifunctionalist viewpoint to cognition (see e.g. Resnick et al., 1997). Also researchers adopting the ethnomethodological stance, such as defended by Levinson (1983), may propound a "theoretical ascetism", judging that the categories of analysis are to be those that the people under study use themselves in making sense of their activity. We consider, however, this position rather "naïve": the final identification of categories is done by researchers who will "see" them through their glasses coloured by their theoretical background —which are, however, to be made explicit. In the present case, our theoretical background provides us with models of the cognitive activities involved in design.

The interactional approach

According to the interactional approach, the analyses conducted concern argumentation and roles (and their interaction). At least two questions are examined:

- how does collective design proceed from the viewpoint of argumentation?
- how does collective design proceed from the viewpoint of roles of the participant designers in actions on the functional activities (such as initiating them, taking them up, rejecting them, etc.)?

This type of analysis is complementary to the functional approach. From a viewpoint of cognitive ergonomics, this step is also necessary to explain deviations between the actual activities and the prescribed task. Again, this step has implications for specifying the nature of the activities to be supported by tools.

"Interactive discourse" is often said to be studied in the context of the "coordination of cognitive activities", i.e. communication, discussion or transmission of ideas, elaborated before expressing them (see e.g. Resnick et al., 1997). We defend, however, the position that such interactive discourse is used not only in order to coordinate cognitive activities, but that it is a cognitive activity in itself which contributes directly to the main task in which it is embedded, i.e., in our case, design evaluation. This position can be related to the one defended by e.g. Teasly (1997) and De Almeida and Saint-Dizier (1998). Teasly (1997) shows how students, working together in a problem-solving activity, engage in a process of explicit problem analysis and justification which leads them to higher levels of problem solution than when they work alone and by themselves. De Almeida and Saint-Dizier (1998) show how the fact of being a team member has an instructional effect, even if no explicit instruction is being provided.

A study of technical review meetings

Our aim is to understand team design activities. From a cognitive point of view, the most common conception of design problems is to consider them as “ill-structured” problems (Eastman, 1969; Simon, 1973; Visser & Hoc, 1990). Their characteristics are as following:

- the specifications given at the start are never complete or without ambiguity: initial problem specifications are not sufficient to define the goal, i.e., the solution, and progressive definition of new constraints is necessary;
- the resolution of conflicting constraints, often coming from different representation and processing systems, plays an important role;
- there is no definite criterion for testing any proposed solution, such as there typically exists for “well-structured” problems: design problem solutions are more or less “acceptable” or “satisfying”, they are not either “correct” or “incorrect”;
- various design solutions are acceptable, one being more satisfying according to one criterion, another according to another criterion.

In our present research, focus is on collective cognitive activities in design, and, more specifically, on a particular activity, i.e. evaluation of design-solution proposals. Our data on evaluation activities, used as illustrated in this paper, come from technical review meetings (TRMs) in an industrial software-development project. The study has been conducted in the context of a France-Quebec collaboration between a team in Cognitive Ergonomics (INRIA-Rocquencourt, France) and a team in Software Engineering (École Polytechnique de Montréal, Canada).

A software-development project involves various types of meetings where team members exchange ideas, elaborate the state of design, evaluate the work done or plan future tasks. These meetings, organised and conducted by software engineers, can be formal or informal. They are of various types, among which design, walkthrough, technical-review and code-inspection meetings.

Various authors have outlined the activities supposed to take place in a TRM (Johnson, 1996; D’Astous, 1997). A TRM may occur after each phase in the global software-development process. It has two main objectives: to verify the current state of the design project and to validate the specifications for the succeeding tasks. This is done on the basis of discussion of a document written in natural and/or formal language. A TRM requires the presence of several reviewers for a certain amount of time (in the order of thirty minutes to two hours). A project team can hold various TRMs during a typical working week.

We collected data by video recording several TRMs. Seven meetings have been analysed. They represent 127 different "sequences". A "sequence" is a series of "verbal moves" related to a same object, here a particular part of the document describing the solution to be evaluated.

The four levels distinguished in our analysis are the following (see Kerbrat-Orecchioni, 1996):

- Move
- Exchange
- Sequence
- Verbal interaction (e.g. a TRM)

The records of the seven TRMs were transcribed into verbal protocols. The coding of the verbal protocols was made at various levels. Previous papers have described our coding scheme in more detail (D’Astous et al., 1998; Robillard et al., 1998a; 1998b).

Coding scheme

Moves

First, a protocol for a meeting was cut up into individual **participant assertions**, according to change of locutor. These assertions were cut up further into "(verbal) moves" according to a coding scheme developed in an interactive way. The coding schemes used in Herbsleb's (Herbsleb et al., 1995) and Karsenty's (1991) studies were examined for this aim. We concluded that none was sufficient to account for the cognitive activities involved in TRMs. Therefore, a new coding scheme was developed, by adding categories and, progressively, in an iterative way, refining the existing ones. The resulting coding of a move is characterised by:

- an activity implemented by a participant locutor;
- an object of the activity;
- an attribute that further qualifies the object and/or the activity.

Each move was coded as ACT/OBJ/ATTR, e.g. a justification of solution S3 with respect to the content criterion "functionality" was coded as JUST/SOL3/CRIT.C(functionality).

On this basis, we cut up each participant assertion into one or more "moves", according to change of activity or object. We identified different types of activities, objects and attributes (see Table I).

Activities	Manage (project or meeting) (MAN) Introduce or read part of the document to be reviewed (INTRO) Request (REQ) Evaluate (EVAL) Inform ("what" or "how") (INFO) Justify ("why") (JUST) Accept (ACC) Reject (REJ) Formulate a hypothesis (concerning the "what", "how" or "why") (HYP) Develop (DEV)
Objects	Solution (implemented in a part of the document to be reviewed) Criterion (form and content criteria) Project or meeting (exclusively object of MAN) Result of a previous activity
Attribute	Form criterion Content criterion

Table I. Different types of activities, objects and attributes

Roles

Different types of roles can be distinguished in a verbal interaction such as a meeting. A first distinction opposes interactional and interlocutive roles (Kerbrat-Orecchioni, 1996). Interactional roles are, e.g. in the medical consultation, those of doctors and their patients. They are relatively stable during an interaction, contrary to interlocutive roles, which are moving.

The interactional roles are still to be distinguished from the social roles occupied by the participants, which refer to the social status and are even more stable —even if also these roles may change.

In the analysis of TRMs conducted so far, we have been focusing on interactional roles. We distinguish three types of interactional roles:

- role at a project level: who is in charge of what in the present project? roles are project leader, (evaluation) procedures expert and co-designer;
- role at a meeting level: who is in charge of what during the meeting? roles are author (of the document, i.e. solution, to be reviewed) and reviewer;
- role at a task level: to which degree a participant is involved in the present task? Indeed, a participant P can be involved directly or indirectly in a task, according to the (technical) interaction of modules in the present task with P's task(s).

Results

The functional approach

Based on our analysis of TRMs using our coding scheme, five types of functional exchanges have been identified —"exchanges" being groupings of verbal moves. These exchanges are:

- **Cognitive Synchronisation (Synch)**: This exchange enables the participants to make sure that they have a shared representation of the state of (alternative) design solutions and/or evaluation criteria (content or form). Individual actions on the level of a move are requesting information, providing information or formulating hypotheses. The objects of these actions may be solutions, criteria or alternative solutions.
- **Review (Rev):** This exchange enables participants to evaluate the value of, or to give their opinion on, (alternative) design solutions or criteria used in the review of a solution. The evaluation can either be negative or positive. Results of a review, especially positive ones, may remain implicit. Individual actions are requesting evaluation or justification, and providing evaluation or justification. The objects of these actions may be solutions, criteria or alternative solutions.
- **Alternative Elaboration (Elab. Alt):** This exchange enables design and analysis of solutions not present in the document being reviewed. Individual actions are developing. The objects of these actions may be solutions or alternative solutions.
- **Conflict Resolution (Conf):** This exchange enables debate between two or more participants regarding a conflict generated by diverging opinions or representations expressed by a rejection. The objects of these diverging opinions and representations may be solutions, criteria, alternative solutions or their evaluation.
- **Management (Man):** This exchange enables coordination and planning. The objects may be the meeting or the project.

We observed that the most frequent functional exchanges were cognitive synchronisation, review and alternative elaboration. Two remarks can be made on the basis of these results. The main objective of TRMs is to evaluate (or review) a document, representing a state of the software design project. However, we found that most time of a TRM is not spent in reviewing activities (38% of the time), but rather in cognitive-synchronisation activities (41%). We also found that the team spends some time in alternative-elaboration activities (21%), which are typical of design, even though, according to the software methodology used by the observed team, the activities in TRMs should not include design.

Furthermore, we analysed the direct objects of exchanges (objects at the first level of exchanges), and the indirect objects of exchanges (objects at the second and more embedded levels of exchanges). At level 1, the objects of exchanges are the solutions to be evaluated. At level 2 and more embedded

levels of exchanges, the objects of exchanges are alternative solutions, criteria, and opinions (e.g., evaluations) produced by participants. The fact that criteria are taken as objects of exchanges at embedded levels indicates that there is cognitive synchronisation and evaluation of the TRM procedure by the participants. For example, the participants explain the nature of a particular criterion for evaluating solutions or they evaluate the criteria by order of priority. This means that one part of the functional activities of the team, which is not prescribed in the TRM methodology, is to make explicit and evaluate the procedure of evaluation.

An example of a coded protocol is given in table II. It illustrates moves, exchanges, levels of exchange, and sequences.

The functional approach, thus, informs us about functional activities related to the task of the design team: how does design search proceeds in the problem and solution space? what are the criteria used for the evaluation of proposed solutions? It also shows deviations of the activity as compared to the prescribed task. The identification of these deviations is important from a cognitive-ergonomics viewpoint. The next step is to explain why these deviations occur. We will see that the interactional approach provides a complementary analysis that may provide this explanation.

The interactional approach

Method of analysis. On the basis of frequent configurations of exchanges, one can qualify argumentative movements which are characteristic of evaluation meetings.

In order to identify such typical configurations of exchanges (i.e. configurations occurring with a significant frequency), instances of two types of method have been used, i.e. two quantitative statistical methods and one qualitative grammatical method. The statistical methods used are Lag Sequential Analysis (LSA) (Allison & Liker, 1982) and hierarchical clustering (Johnson, 1967); the grammatical method is the application of rewriting rules (Gonzalez & Thomason, 1978).

These methods have been used in an iterative way, in several cycles, as long as LSA allows significant configurations to be detected. One or more rewriting rules are applied on the results of each cycle.

The analysis of sequential structures using LSA is grounded in information theory. LSA enables the identification of units (moves, exchanges) that follow each other, with or without other units in-between. The analysis consists in determining whether or not the frequency of a given unit is independent of the frequency of another one. Sequential structures enable the definition of configurations.

On the one hand, this approach can validate groupings identified by psychologists using qualitative analysis (such as the exchanges presented above) and, on the other hand, psychologists possess cognitive models which are of help in interpreting and validating the configurations identified by the statistical approach.

Rewriting rules are used in order to group occurrences of configurations in a structure into new units. Hierarchical clustering is used in order to examine similarities inside sequential structures. Both are utilised as long as the LSA applied on the new resulting structure provides significant outcomes (i.e. exchanges or sequences).

part	id	move (protocol segment)	move (coded)	exchange	lev	seq
	51		INTRO/SOLed		0	
B	52	Why did you put 150 there?	REQ/JUST/INTRO51	REV	1	
M	54	I don't believe in using 150 DEFINE. These will do the same thing, but the compiler will check them while the compiler doesn't check DEFINEs.	JUST/INTRO51/CRIT.Ca	REV	1	

C	57	There may be more than 50 error messages, you know!	HYP/INTRO51	SYN	1	
M	60	Ah no, this is just a type, like the type of the message itself.	REJ/HYP57/CRIT.Ca	CON	2	
C	61	Euh, euh.	ACC/REJ60	CON	3	
M	62	It's just that I need, I need some fields OK, these four fields there!	INTRO/SOLee		0	
M	63	Because I need some fixed arrays at the start for the messages.	JUST/INTRO62/CRIT.C	REV	1	
M	64	So, I fix them, I fix the first four. The additional messages will follow. We'll be able to put whatever we want, an error message, insufficient memory.	INFO/INTRO62/CRIT.Ca	SYN	1	
B	65	Why then if we can use them any way!	REQ/INFO/INTRO62	SYN	1	
B	67	Yeah, OK, we don't have a choice.	ACC/INTRO62/CRIT.Ca	SYN	1	2
M	68	We can do it here.	INFO/INTRO62	SYN	1	

Table II. Example of coded protocol

Results: Argumenative movements. In our functional analysis of TRMs, we found that the most frequent activities were cognitive synchronisation and review, followed by alternative elaboration. This led us to suppose that there is a tight connection between cognitive synchronisation and review (translating evaluation which one might suppose to be typical of TRMs) on the one hand, and between review and design (supposed to be actualised, mainly, by elaboration of —alternative— solutions) activities on the other hand. Through the present analysis in terms of exchanges and sequences, we have examined the nature of these supposed relationships.

After a certain number of cycles consisting of LSA and rewriting, followed by a hierarchical-clustering step, the following links between exchanges have been identified as significant at $p < .05$ (see Figure 1).

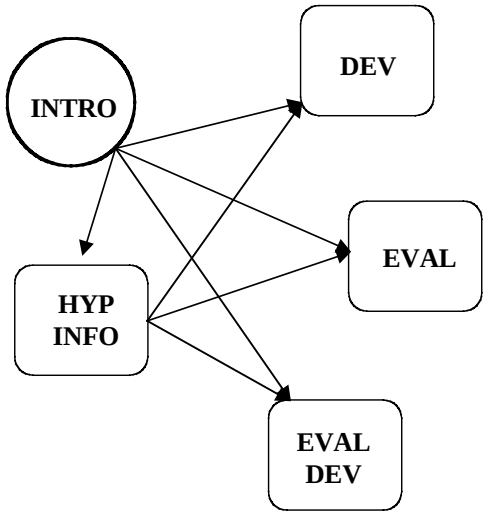

Figure 1. Sequential structures in TRMs

Legend


represents a move


represents an exchange


represents a significant transition

This figure may be read as follows. When introduction of a solution (INTRO) is followed immediately by a development (DEV) (which consists in changing the form of the solution), this development of an alternative solution is the consequence of an negative evaluation (according to a criterion of form) which has remained implicit. Introduction of a solution can also be followed immediately by either its evaluation alone (EVAL) or its evaluation and development of an alternative solution (in one order or another, i.e. DEV-EVAL or EVAL-DEV). Such review activities may, or may not, be preceded by a cognitive-synchronisation exchange (HYP-INFO or INFO-HYP). In these latter cases, the evaluation bears mainly upon content criteria.

With respect to the relationship between review and cognitive synchronisation: when review is introduced by cognitive synchronisation, this means that a shared representation of the to-be-evaluated object may be a prerequisite for its review to take place. The argumentative movement is of the type “proposition-opinion”.

With respect to the relationship between review and design: the review of a solution, in particular a negative review, leads participants to develop alternative solutions: such a solution may be a justification for the negative review or an answer to the current rejection. The argumentative movement is of the type “opinion-arguments”.

N.B. On the surface, an argument may be presented, either before the opinion it supports is presented (DEV-EVAL), or afterwards (EVAL-DEV).

On the basis of this interactional approach, we see that the functional activities of elaboration of alternative solutions and of cognitive synchronisation, even if not expected to occur in the TRM prescribed task, are both necessary and useful in the collaboration taking place through argumentation.

Other questions that may be examined are, e.g., which (persuasive) tactics do participants use in order to get their favoured design-solution proposal adopted? which tactics do participants use in order to avoid and resolve conflicts over their proposals or other representations (see e.g. Cross & Clayburn Cross, 1996)? which are the conditions and modalities of negotiation (see e.g. Brereton et al., 1996)?

Results: Roles. Which is the effect of participant roles on design actions and objects: who initiates a solution proposal, who comes up with new elements related to the use of evaluation criteria, etc.? Different hypotheses can be formulated with respect to the effect of roles. E.g., one may expect that according to one's role at a project level, a participant will intervene or not, or intervene more or less, on certain content topics of the document under discussion. The effect of the three types of roles has been examined using a χ^2 ($p < 0.05$).

We found that the type of criterion which is used depends on the role of the participant at the project level (see Figure 2).

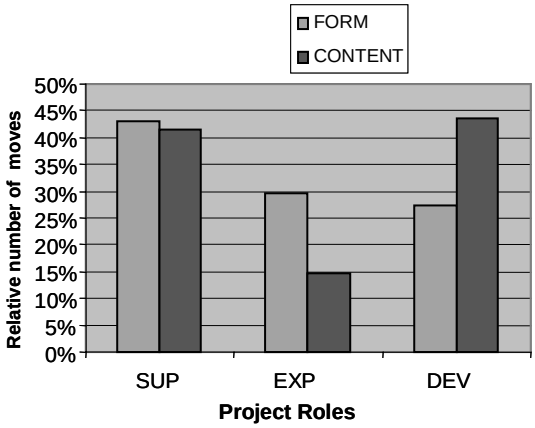

Figure 2. Effect of role in the project on a participant's use of criteria

The co-designers (DEV) refer more often to content than to form criteria, the procedures expert (EXP) refers more often to form than to content criteria, and the project leader (SUP) refers to both content and form criteria.

An interaction has been detected between the role at the project level and the role at the task level (see Figure 3).

Whereas co-designers get more often involved in moves where their interest is "direct" as regards their role at the task level, the reverse is observed for the project leader and the procedures expert: they intervene more often where their interest is "indirect" as regards their role at the task level. One may interpret this result as the project leader and the procedures expert being more concerned by the entire project and not only by particular sub-tasks.

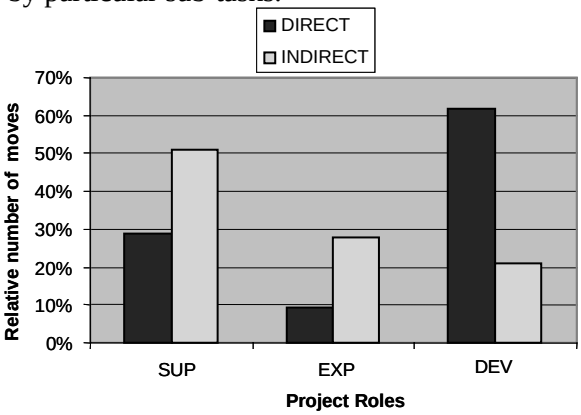

Figure 3. Interaction between role in the project and role at the task level

Conclusion and implications of results

In summary, our approach combines both an analysis of functional activities and of interactional activities in design team work. We have seen that both these approaches are useful and complementary to understand the team activity in TRMs, i.e., evaluation meetings. A next step would be to analyse how these approaches account for team activity in design meetings. A further step would be to evaluate how these two approaches apply to other types of tasks, e.g., process control.

Tools, both for individual and for cooperative tasks, are not necessarily materialised in computerised systems. They may also be methodological. An example on the basis of our study is the strong suggestion to introduce cognitive synchronisation in the methodology for evaluation meetings. Given the observation that cognitive synchronisation often constitutes a prerequisite for review, and given the duration of all the synchronisation exchanges in each meeting, one may imagine that the

institution of an explicit synchronisation phase at the beginning of each meeting or each sequence (i.e. discussion of a part of the solution implemented in the document under review) may, at the one hand, spare time, and at the other hand assure that the co-designers have a shared understanding of the object under discussion, and not only of those elements which, by chance, have been the object of synchronisation.

Implications of our results for (computer-supported) tools may be seen under several directions. The analysis of functional activities in a team highlights what are the actual activities of a team performing a prescribed task. The identification of these activities is essential for the specification of tools. From our analysis of TRMs, we show that these functional activities cannot be completely inferred from the prescribed task of the team. In this case, the activity of design-solution evaluation is prescribed. However we observed other activities of the team, especially design and cognitive synchronisation. Thus the functional approach allows the specification of activities to be supported for a prescribed task. Depending on the nature of these activities, the choice of the kind of support may be different.

This type of analysis highlights also the nature of the objects which are discussed by the team. In this case too, they may be different from what is prescribed by the task. In our study, we showed that the solutions to be evaluated are of course objects of exchanges, but that there are also other, indirect objects of exchanges, e.g., criteria.

Thus the identification of functional activities allows to structure e.g. CSCW tools in terms of activities to be supported and objects around which exchanges are organised.

The analysis of interactional activities in a team highlights the importance of roles and argumentation for specifying tools.

With respect to roles, significant results were found in this study at the project and task levels, and in relation to the discussion about the two types of criterion. At a more general plane, however, one may assert that different degrees of participants' involvement with respect to activities (at the level of moves, exchanges or sequences) or objects, depending on their role, has implications for tools with regard to possible work spaces devoted to participants with different roles.

The role analysis performed in this study has, however, some limitations: as this study was performed on only one project team, project roles were linked to individuals and remained the same throughout the study. Other studies on similar projects would need to be performed to generalize the results.

Another implication is methodological and organisational. The observation that co-designers' involvement in moves is relatively confined to tasks in which their interest is "direct" may lead to the idea to encourage or even oblige co-designers to involve also in tasks in which their interest is only "indirect".

With respect to argumentation, we already commented upon the methodological implications of the relationships we found between review and cognitive synchronisation, and between review and design. Concerning (computer-supported) tools, two directions may be adopted, the support of collaborative activities and that of design-rationale construction.

Ever more researchers and practitioners insist on the importance of constructing design rationale(s) for a design project. An often noticed problem, however, is that such construction is felt by most designers to be a supplementary task in design meetings. In the present study, we observed that, during evaluation meetings (TRMs), many knowledge elements relevant to design rationale are made explicit "spontaneously". They were during cognitive synchronisation and during review, in the opinion part of argumentative movements of the type "proposition-opinion" and of the type "opinion-arguments". Combining these two movements into a "proposition-opinion-arguments" unit might suggest a framework for argumentation with three "cases". Such a framework may be the basis for a support structure to collaborative activities during evaluation meetings such as TRMs.

The arguments advanced can be justifications or alternative solutions. These are both central elements of design rationale. Proposing a support structure for activities in which they are involved

allows them to be organised into a design-rationale record. This could be used as a "project memory" document. The actual use, however, of such a record should be confronted with that of other proposed formalisms for design rationale (e.g. Q.O.C), in order to examine its usability (see Shum & Hammond, 1994).

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