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ARGUMENTATION ANALYSIS IN AN UPSTREAM PHASE OF AN INNOVATION PROJECT

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Abstract

Nowadays the innovation process has become a collective activity where designers have no longer to work only in their own field of expertise but they have also to work with others in project meetings in order to make decisions collectively. The main purpose of this study is to understand how participants argue and converge toward one solution in an upstream phase of an innovation project.

Our work is based on a case study. We captured video and audio data and we gathered working documents from an innovation project meeting in a French company. Our first macro analysis showed that during this meeting there were no explicit decisions concerning both technical and business model solutions. We also noticed that the technical discussions converged towards a solution. This convergence was based on a multitude of mobilized criteria that we structured in different categories. In future research we plan to carry out micro analyses of particular moments highlighted in our current work in order to understand this convergence process.

Keywords: Innovation, Collaborative design, argumentation, convergence, Decision making

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1. INTRODUCTION

Idea generation and selection are important parts of engineering process innovation during the earlier fuzzy front end steps (Ferioli & al., 2010). Concepts to develop are chosen during these stages and decisions made determine the success of innovation development phases. The paper focuses on the under-standing of fuzzy front-end activities, on what is being discussed, on which decisions are made, and on how they are agreed upon during design meetings.

There have been many attempts to define innovation. (Hester & al., 2011) give an interesting definition, from a governance perspective, of the innovation: *Innovation represents the exploitation of, or value creation from, new ideas manifest as products, processes, or combinations of the two. It may therefore be characterized in terms of novelty and use*. The work presented here focuses on product innovation. Based on the definition below, innovation is considered more than product ideation but has to take into consideration the market and the users, as it is the sole guarantee of value creation. This paper looks at decisions in the fuzzy front-end innovation process that take into account mixed criteria related to the market and the product in collaborative design meetings.

Furthermore, nowadays products are increasingly mixing multiple technologies, including mechanical, electrical and electronic aspects. Smart products even include embedded systems and complex mechatronics. Expertise from these different fields has to feed idea generation and selection. For competitive reasons, the articulation between fuzzy front-end and development processes must become as fluid (if not seamless) as possible in order to take into account as early as possible the needs and constraints of the entire product life cycle. Innovation projects require intensive interdisciplinary teamwork, including stakeholders from technological and non-technological expertise (Anbari, 2005). They are involved in benchmarking, ideation, creativity and selection activities during the early phases of the innovation project. Experts must then build a common goal and a shared understanding of the problem including the product, the market and other elements of the product environment. These are all translated into criteria from their respective fields thus allowing for argumentation and decision-making.

Decision-making is often treated in the literature as a selection process carried out within a consensus-based approach where known criteria are weighted and organised in a hierarchy for solving a multi-criteria design problem (Wibowo & Deng, 2013). In the engineering design context, many authors (Dorst & Cross, 2001) argue for co-evolution between design problem and design solution, meaning that many criteria will emerge from an interaction between designers and the representation of the problem they are collectively building. This is why the paper focuses on the study of interactions between designers belonging to product development teams or more particularly in the case of this paper, the fuzzy front end innovation. Among interactions in a collaborative design context defined by (Lund, Prudhomme, & Cassier, 2007) argumentation is of great interest for us. (Prudhomme, Pourroy, Lund, 2007) defines argumentation in design as a cognitive and an interactive operation through which actors seek to convince each other by the meaning and the validity of a solution, a requirement, or the relationship between both requirements and solution. Criteria and metrics associated are defined as basic elements that characterize requirements.

According to this point of view, our objective is to understand the fuzzy front end activity of collaborative innovation projects by analyzing argumentation developed by the participants during these initial project phases. The purpose of this article will be to elicit and track criteria, to access the way they were used by participants and to analyze the convergence towards particular solutions. Within this perspective, a particular design session in an industrial company had been observed. Interactions were recorded coded and analyzed. During this session the product and the target market had to be defined. A multidisciplinary team from the company was gathered to generate ideas and to evaluate their feasibility.

In the following sections, first the positioning of the research context is presented through a review of the literature, briefly describing where the activity studied is situated within an innovation process and more deeply what argumentation model exist in the engineering field. Then a justification of the research methodology adopted is given, including the case study description. Next, the analysis made and the results obtained will be described. In the last section the results, the contributions of the work done and some research perspectives will be presented.

2. THEORETICAL FOUNDATION

(De Fontaine, 2014) claimed that the objective in an upstream phase was to support a type of go/no go decision-making on investments towards development. But all ideas and concepts studied were not necessarily developed. In incremental innovation, it was advised (Sperry & al., 2009) to move towards a linear process of an upstream management of an innovation process. (McGrath, 1992) structured the upstream phase of product innovation processes by five bottlenecks, inspired by the model of (Wheelwright & al., 1992), illustrated in figure 1. As designers progress in the process, some ideas are rejected while others are refined. The transition from one step to another is formulated by a decision. (McGrath, 1992) included the evolution of concepts, their specifications and the schedules in the upstream phase.

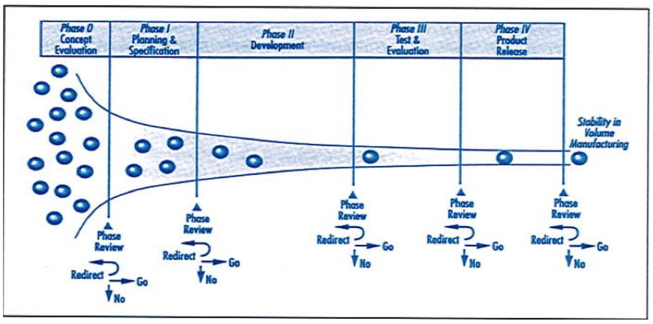

Figure 1. Funnel of innovation (McGrath, 1992)

The work to do takes place in the first part of the funnel (Phase 0, Concept evaluation). In this phase, the objective is to generate ideas and to evaluate them for selecting the best ones from the different experts' point of views.

In order to trace design interactions and argumentation in particular, we must give specific attention to design rationale (DR) models. (Maclean and *al.* 1989) defined DR as the argument behind the artefact. Its content was an idealization of the design space and a co-product of design

Table 1. Models: IBIS / COQ / DRL

Model	Objectives	Nodes
IBIS (Issue Based Information System)	To provide support to structure the discussion so that the information can be captured and organized, helping developers to solve their problems	QUESTIONS: problems under discussion POSITIONS: possible solutions to the problem ARGUMENTS: favorable or unfavorable opinion on the various solutions sought
QOC (Questions, Options and Criteria)	The model presents a context based on the process that showed how the solutions are generated and evaluated	QUESTIONS: The main problems to solve OPTIONS: the alternatives identified to solve the problems CRITERIA: justify existing options EVALUATIONS: Relations between options and criteria
DRL (Decision Representation Language)	The main concerns are to increase the expressiveness and the functionality	DECISION PROBLEMS: A controversial issue in the project GOAL: A set of requirements (criteria) to fix ALTERNATIVES: Possible solutions to the decision problems RECLAMATIONS: Used to argue QUESTIONS: Used to lead discussions during the project PROCEDURES: Measures that should be taken to get answers to a question

It included also alternative options and reasons for choosing specific ones. It is supposed to help designers to solve problems, to assist them thinking about a design and to communicate with other

designers to better understand the design. Concerning end users, it is supposed to help to improve the communication while taking into account the intentions of original designers.
Three concurrent DR models exist in the literature: IBIS (Conklin & Burgess-Yakemovic, 1996), QOC (MacLean, Young, Belloti & Morin, 1996) and DRL (Lee & Lai, 1996). Table 1 describes the objectives and the basic concepts of each model.

All of these models contain at least the three following concepts: the design problem considered (question or decision problem), possible solutions that were considered (position, option, alternative) and arguments that support or challenge these solutions (argument, criteria, reclamation). These three concepts are retained as basic elements in this approach. However these models were developed for analysing designers working alone and in project development, therefore they do not take into account the current collaborative conditions of upstream innovative processes.
Collaborative design involves communication for enabling collective decision to arise. (D. Rieke & *al.,* 2008) claim that argumentation is a communication process, which means it involves engaging people's minds through interactions. Argumentation is inherent in collaborative decision-making and aims also at sensitizing people to their own argumentative behaviours and to provide new information to help them to be as effective as possible. In addition, responsibility for decision-making is shared, including the responsibility for bad decisions. (Cassier, 2010) proposed a Design Interaction Framework (DIF) grid to analyse project review interactions in a project development context. He divided the grid into both topics that were under discussion (project, task, tools, communication, solution, criteria) and dominant pragmatic functions (management, proposition, explanation, argumentation, opinion). Note here that the three above-mentioned basic concepts i.e. task, solution and criteria, which are elements of the topics classification, are found again, but also argumentation defined as pragmatic function.
From this literature review, it was highlighted from DR and DIF three concepts as relevant for analysing collaborative design activity: task or design problem, Solution alternative, criteria support for argumentation. The decision to select them for analysing collaborative fuzzy front-end even if they were developed for project development purposes has been taken. Are these key concepts relevant for analysing fuzzy front end of an innovation process? From this analysis, is it possible to characterize how are selected the solution(s) the team decide to deepen? Is there a convergence approach that can be elicited? Which are the core element(s) of this convergence?

3. THE CASE STUDY METHODOLOGY

The work done is the analysis of a case study (Voss & al., 2002). It is going to be presented in this part of the paper. It includes, the introduction of the company, the methodology adopted to analyse the data collected, and finally the enumeration of the different steps of the research project.

3.1 Situation description

The research is based on a case study built over a project meeting within the business unit of large French company. This company is belonging to a worldwide leading group operating in the field of small electrical appliances. In order to face global competition, the firm focuses on innovation and, to do so, allocates a large budget for developing an innovation oriented portfolio. Innovation is seen as a key driver in differentiating products and opening new market segments. The Group also relies on innovation to provide products for mature and emerging markets (BOP markets).
As previously stated, innovation projects involve several phases from idea generation to commercialization. In this company, these steps include upstream projects that aim to come up with innovative products. It is considered here that one of these projects and more particularly one meeting that occurs when the product and the market are still largely undefined. The multidisciplinary team is gathered to discuss the project feasibility according to the needs they already spotted. This team is composed of six members from different domains of expertise (Innovation Group Leader, product designer, anthropologist, project innovation leader …), who are all working in the company. In a concurrent engineering perspective, it is important to gather all the expertise that might impact the final decision of going ahead, or not, on this project. This meeting lasted eight hours, divided into three parts: 1) the morning meeting was mainly about the presentation of the objectives to be reached by the end of the day and the organization of the meeting including a description of existing products,

2) a lunch break that was also dedicated to user experience of existing products on the market and 3) an afternoon meeting where the discussion was based more on the project and its feasibility. All the data provided in this paper were captured during this meeting.

3.2 Data collection and processing

The research team went to the company in order to record (audio and video) the upstream project meeting. The meeting was held in the same meeting room, except for the lunch that was relocated outside of the building. In order to cover the entire room (including the screen used for the slideshow and a paperboard), three cameras were set up allowing covering the different angles of the room. Personal microphones were provided to every participant. Furthermore, a Go-Pro was used to take a series of photos during the meeting and record the outdoor session. The research team left the room before the beginning of the meeting in order to prevent any disturbance in the debates. After recording the meeting, the videos and audio streams were synchronized. In addition, the documents that has been used and produced during the meeting were collected.
Finally a complete speech transcription of the height hours has been done.
The first step prior to the analysis was to visualize the recorded videos and get an overview of the whole meeting. QuickTime Pro software was used to ease the management of simultaneous view through the thumbnails mechanism (Figure 2). After several visualisations of the video, the meeting was divided into fifteen episodes according to the following criteria: objectives as formulated in the schedule of the meeting or announced by the animator, main objects used as support for the conversation, timing and principal participant. This initial work led to the identification of episodes where solutions emerged from the debates. The episodes selected were those considered as worthy to be analysed because they were containing information and details on the project and the benchmarking elements.

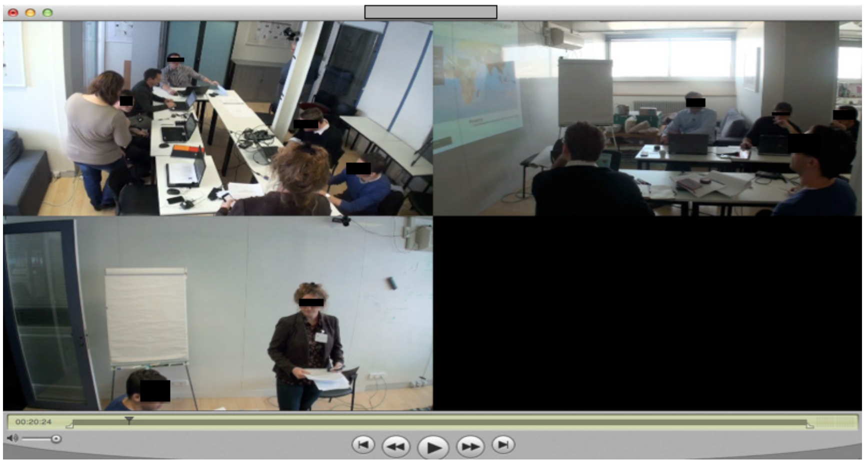

Figure 2. Vignetting of synchronized videos of the meeting using QuickTime Pro

4. ANALYSIS AND RESULTS

In order to analyse the chosen episodes, an analysis grid was defined, that contained all elements judged as important for the study (cf. next section). This grid was used to understand the interactions between the project team members and to conduct a macro analysis which allowed setting up a representation that showed the succession of solutions' evocation. The grid built included different criteria that helped the understanding of the argumentation underlying the convergence toward a solution. These criteria were organised into general categories reflecting the direction in which argumentation was taken by the participants.

4.1 Analysis grid

The first output of this study is the analysis grid presented hereafter, used to analyse designers' argumentation. Unsurprisingly, the literature review led to conclude that none of the existing models related to decision-making processes could be applied "as-is" to the context of the research. However, there are similarities that exist across models and two elements of this grid (solutions and criteria) were taken from the general literature and from (Cassier, 2010). Two other elements emerged from the pre-analysis of the corpus: actors and objects. These four elements were grouped in the following analysis grid (see Figure 3). In this framework "actors" stands for project team members, "objects" stands for prototypes, product examples and documents, "solutions" stands for both Technical Solutions (TS) and Business Model Solutions (BMS) and finally "criteria" stands for every utterance used by the participants for developing ideas or arguing about them.

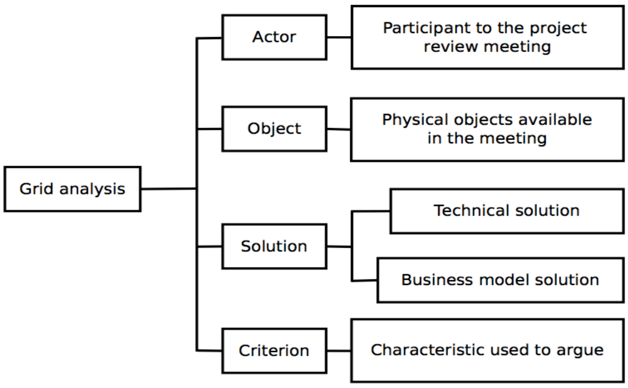

Figure 3. Analysis grid

In the following the focus will be on the analysis of the solutions and criteria categories (Figure 3).

4.2 Convergence towards a solution

All the solutions mentioned by the designers were marked down each time they occurred. Seeking for the trace of decision-making and the influence of argumentation, it was important to understand why solutions may appear more than once and to notice when they finally were left aside or abandoned. Observation of the project meeting showed no clear decision-making moments that could be considered as a formal decision. This was deduced from the absence of any evident clue that would have indicated a formal group decision: explicit decision about a solution, vote or other kind of decision process... So, in an attempt to understand more precisely how a final decision have however been achieved, a representation was constructed to represent the number of occurrence where solutions appeared during the meeting (Figure 4).

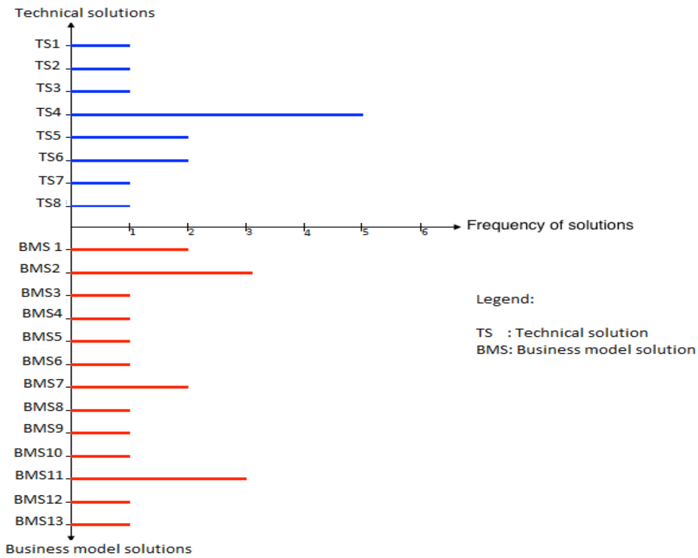

Figure 4. Number of occurrences of solutions during the meeting

The naming of solutions in Figure 4 corresponds to their chronological appearance. The number of occurrences is signified by the length of the line on the graph. Solutions are rendered anonymous due to confidentiality.

In order to access the dynamics of the debates, a time-based analysis was conducted. It allowed to monitor when highly discussed solutions appeared (thanks to the number of occurrences previously calculated) and to locate them precisely in the identified episodes. Figure 4 displays such occurrences on the meeting timeline. It should be noted that some solutions were discussed more than once (TS54, TS55, TS56, BMS1, BMS22, BMS7, BMS11) and some of these were discussed more than others (TS54, BMS2, BMS11).

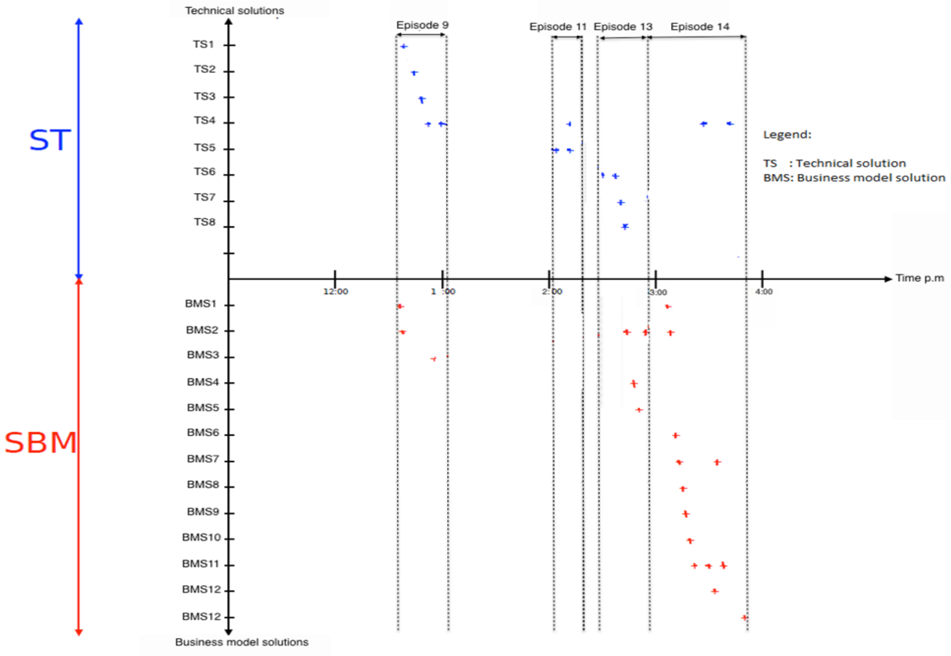

Figure 5. Solutions over time

Figure 5 shows the time at which each solution began to be discussed but does not give any information about the time spent on discussing the solution. One can easily note when the most discussed solutions appear, both technical and business.

Given the knowledge of the corpus and the different solutions discussed that cannot be presented in details (for confidentiality sake), it was supposed that both technical and business model solutions were linked, which means that business model solutions were proposed after a discussion about a technical solution. Business model solutions were modified or discussed only after a technical solution has been proposed. For example, going back to episode 14, only one technical solution was proposed while several business model ones were studied (BMS2 — overlapping with episode 13 — and BMS11).

Figure 5 also shows where the discussion on the most discussed technical solution (TS4) occurred (episodes 9, 11 and 14). The fact that one technical solution was increasingly discussed as the meeting went on (while others were dropped) led to the conclusion that, despite the absence of formal or explicit decision-making during the meeting, there was indeed slow convergence toward a solution (TS4). However, this is a limited macro analytic view and thus it was important to look more closely at the criteria themselves to illuminate the role they had in this process.

4.3 Criteria categories

The objective here was to search for factors that could speak in favour of the convergence towards the technical solution mentioned above. During the meeting the participants used many criteria. In order to compare with existing literature and to carry on the analyses, a list of every criterion appearing in the transcription of the meeting was established. After this rough enumeration, they were regrouped into categories according to three aspects: nature, family and example (cf. Table 2). The categories were organised from the general to the particular. They were studied to determine the extent to which they influenced the convergence detected and to ascertain which criteria were instrumental.

Table 2. Criteria's nature/ Family criteria/ Criteria

Criteria's nature	Categories of criteria	Criteria
Business model aspect	Local characteristics - Human and social	Work, CR1...
	Local characteristics - infrastructure	CR2...
	Life cycle	Problem Detection Production, ...
	Economic	Market Sale, ...
	Positioning the company	Added value Legitimacy , ...
Technical aspect	Manufacturability	CR3...
	Technical performances	CR4...
	Electrical energy	CR5...
	Technical structure	Dimensions Architecture, ...
	Category 10	CR6...

Some criteria were coded in Table 2 in order to protect the confidential nature of the R&D project. Note that all criteria were either related to technical aspects of the product or to the business model. The criteria families were designed for the purpose of describing their nature with more detail. Finally, the basic criterion formed the last part of the division.

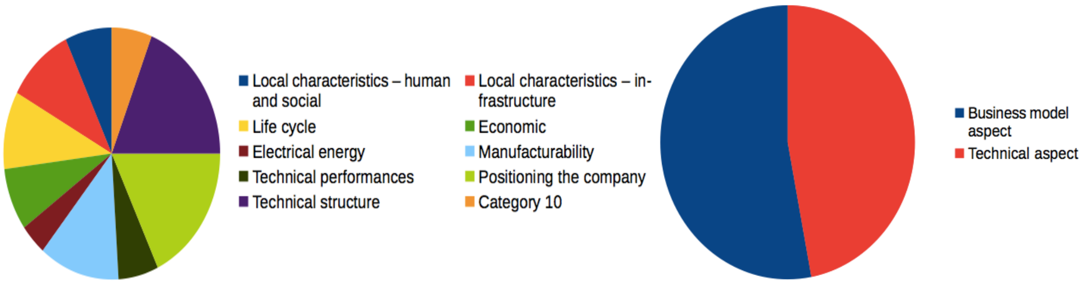

Figure 6. Number of occurrences of both family criteria and criteria's nature in percentage

The work is in progress and the results on the criteria have not yet been validated by the company nor situated within the literature as they have been empirically inferred from the analysis of the video.
Concerning the criteria classification ("category 10" is not explicit due to confidentiality reasons), the number of their occurrence was represented to see which ones were discussed the most during the meeting (Figure 6) and how often they appeared in the meeting.
It clearly appears that there are criteria categories that are discussed often, such as positioning the company (dealing with the legitimacy of the company to position itself on this market segment) and technical structure. This led us to hypothesize that they might have an influence on the convergence towards a technical solution.
The next step was dedicated to the exploration of the relationship between criteria mobilisation and convergence to a solution. It led to the creation of a new visualization that was chosen to represent the use of the criteria categories over time (Figure 6). It shows the density of the criteria families during the meeting thus giving an idea of their preponderance in the debates.

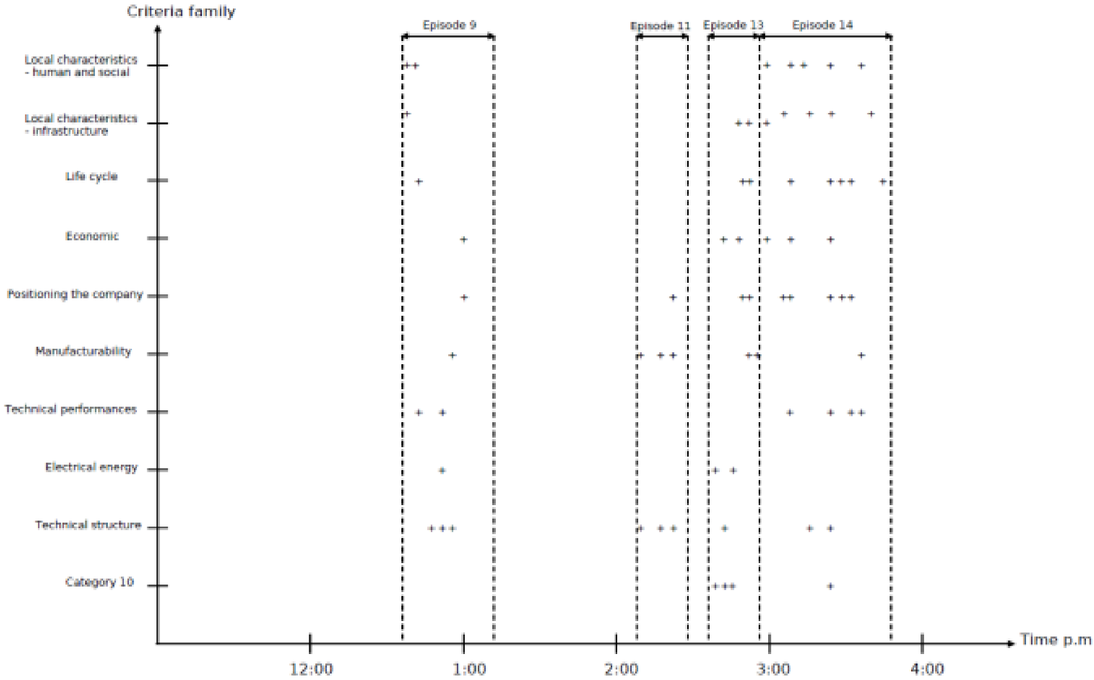

Figure 7. Criteria families mobilized during the meeting

It can be seen from the figure that different criteria families are discussed often. Going to episode fourteen (14) it can be seen that more criteria families are evoked in this episode (by the end of the meeting) than in earlier ones (the beginning of the meeting) and that many are mobilized more than once. This gives support to the argument that the team prefers solution TS4 that appeared in episode 14. Two sets of results lend credence to this: 1) the number of times solution TS4 is mentioned and 2) the number of arguments used to challenge or support solution TS4.

Figure 7 illustrates much greater amounts of criteria being discussed by the end of episode fourteen (e.g. positioning the company, life cycle and technical performances) and may therefore also illustrate first the convergence toward the technical solution at that point and second, which criteria are important for converging. Undergoing study is performed by doing micro analyses of the moments where this convergence might be happening and that could be assimilated to pivotal moments (Lund and *al.* 2013).

5. CONCLUSION AND FUTURE WORK

This article concerns the argumentation and convergence toward a technical solution in the first stages of an innovation project. Its objective was to understand how the meeting recorded progressed and how all project team members seemed to agree on a technical solution, while specifying the elements that led to this agreement.

An analysis grid was constituted based on elements taken from the literature review and regrouped together so as to observe how the designers converged toward one technical solution. Also to consider some argumentative elements — in the form of specific criteria — that led to this convergence.

The main results are the different representations and their analysis that showed that in this project meeting a convergence towards one technical solution is observed, starting with the detection of solutions, the one chosen, the criteria used to argument towards it, but that there are no formal decisions that explicitly confirm that convergence. In order to understand how this convergence could come about, the criteria used by the designers were detected and classified.

These results can't yet be generalized to other situations in that this work is based only on one recorded meeting. Yet, such a rich and detailed analysis sets the stage for further work. Another limitation of this study is that the authors and the artifacts used during the meeting were not considered and that will be the purpose of future works.

Further analyses are still in progress, which consider all the grid elements in order to link the macro analysis to an even more detailed micro analysis. The work has several perspectives, starting with a deeper study of particular moments that might be pivotal for decision-making.

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