ON THE USE OF ANNOTATION FUNCTIONALITY IN PDM TOOLS TO FOSTER COLLABORATIVE DESIGN PROCESSES

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Abstract:

Co-operation processes during design projects are quite unstructured. The confrontation of the different actors' points of view leads to informal information exchanges. In this paper, two industrial case studies illustrate this assumption. First one deals with a validation process which is a predefined process at a global level. Second one concerns the early phases of product design projects that can be suitable for the introduction of technological innovation. We analyse in both case studies how co-operation can be supported by the way of annotations in collaborative tools. In the first one, a Product Data Management (PDM) system is used to foster the co-ordination of actors' activities by managing documents and annotations. For the second one, which is based on a socio-technical study of the innovative process, a configuration of a PDM solution and a specific collaborative tool named ID² are proposed. These tools propose semi-formal information structuring in order to promote interactions between actors. The results are discussed and the comparison between formal and informal processes allows establishing an evaluation of the interest of existing tools versus specific implemented tools.

Key words: Annotation, Co-operation Processes, Product Data Management, Innovation, Industrial Case Studies

1 Introduction

It is now a well-established fact that the design process of a manufactured product is complex and takes place within conflicting contexts combining technical, economical and social aspects. More over, research within concurrent engineering points the difficulties of design work at the interfaces between professional skills and jobs [6] and the necessity to propose new tools to support the interactions between actors. The main objective is to foster multidisciplinary collaboration among actors who have different points of view and build different representations of the product. This point implies to develop new way of interaction between them and taking into account of their differences of culture due to their domain of expertise (design, manufacturing, marketing, sales, etc.). Among possibilities of interactions, annotations are a natural way for adding information to a specific representation. Most of the time annotations remain informal and are considered as mere supports to a verbal exchange. It is important to consider annotations as complex and composite elements which can play a central role in design co-operation [1]. We address here the problem of structuring these annotations in collaborative tools, and we show how they can foster knowledge creation and participate to the development of shared understanding among design teams.

Our main objective is to analyse co-operation and co-ordination mechanisms into design processes and to propose adequate collaborative tools in order to manage actors' information. In the following section, one industrial case study is introduced and analysed to highlight the characteristics of collaboration between designers during a predefined validation process. According to this first case study, a PDM tool is configured to manage annotations during this process. Then, a second industrial case study is proposed in section 3 to illustrate the characteristic of non predefined process and especially during the pre-design phases of innovative product. In section 4, two alternative solutions are detailed to support the non-structured information between actors. Finally we discuss about the characteristics of each case study process and about the suitability of the proposed annotation management functionalities.

2 Collaboration and annotations management in predefined design process

2.1 PDM tool in a validation process

We work on a first industrial case study with a prime contractor specialised in aeronautical engines. This company is engaged in a long term project of Windchill PLM system integration [14]. One subpart of this project deals with the deployment of a validation process based both on Windchill and on its associated collaborative tool called Product View. During a design project, an aero engine is divided into sub-assemblies. Each design department team has the responsibility to define one of them. A validation process must be engaged in order that designers have a feedback from the different industrialisation teams. Collaboration between design and industrialisation actors is under the control of the PDM system and the collaborative tool. The main principle of this process is that each industrialisation actor who notices an error, a possible warning or only a comment generates an annotation linked to the right element of the sub-assembly. Design actors are then able to analyse these annotations and to realise the necessary modifications.

Initially Product Data Management (PDM) systems have been developed to manage product data and especially within predefined design process [13]. They give to the right person the right information at the right time and with the right format. They now manage the whole product life cycle as Product Life cycle Management systems [15] and evolve towards the « Collaborative Product Commerce ». [3] identifies five functions. First PDM manages documents, their access and evolution. Second it manages their life cycle using workflows in order to automate and to control the evolution of product data through predefined tasks [12] [5]. Third it allows product data structuring and configuration. Four it manages product classification functions. More recently it proposes some project management functions. With the development of Internet-based technologies, PDM systems offer new functionalities, already existing in groupware systems [8], to foster collaboration between actors. Indeed, teams involved in the design process are composed of people having different skills, belonging to different departments or companies, and having different responsibilities. They need to validate technical aspects of the project through the integration of all the components of a complex product. This point implies to develop shared supports allowing common understanding and informal interactions among designers in order to not forget any aspect in the validation process. In this sense, we study here how informal information can be associated to documents as annotations. We present in the following section the proposed solution for the validation process based on annotations management.

2.2 Annotations structuring based on a PDM tool

Within Windchill each stored CAD model is associated to a graphical model which can be viewed with the collaborative tool Product View. This graphical model can be modified but when a new version of the CAD model is generated, previous version of both CAD and graphical models are stored and a new graphical model is generated without annotation.

Based on these considerations, a sub-assembly model is associated within Windchill to a specific life cycle and a workflow taking into account the validation process. When the sub-assembly is generated designers must integrate in the graphical model all the related drawings. When they have finished the state of the sub-assembly model changes: industrialisation actors can access to the sub-assembly model. During this state, they can introduce annotations on the graphical model. When each concerned actor indicates to Windchill that his task is achieved the sub-assembly model comes back to a modification state and a new version is generated and proposed to annotations. This sequence is iterative until no modification is needed. Then the sub-assembly model takes a final state.

Industrialisation actors make annotations on the drawings or on the 3D parts. As information in Product View is managed as a whole (all is stored in the same file), specific guidelines have been formalised in order that industrialisation actors classifies properly their annotations and in order that design actors can retrieve and understand them. For example in figure 1, two annotations have been associated to the same drawing. Actors must give two significant names manually. To propose an annotation concerning an existing one, it is necessary to make a copy of the first one with a name indicating the relationship ("tolerance problem" and "tolerance problem 2") and then to add new information. By this way, annotations history can be manually stored. Figure 2 is an example of a 3D annotation. The spatial position defining the context of the annotation is stored to facilitate the design actor understanding.

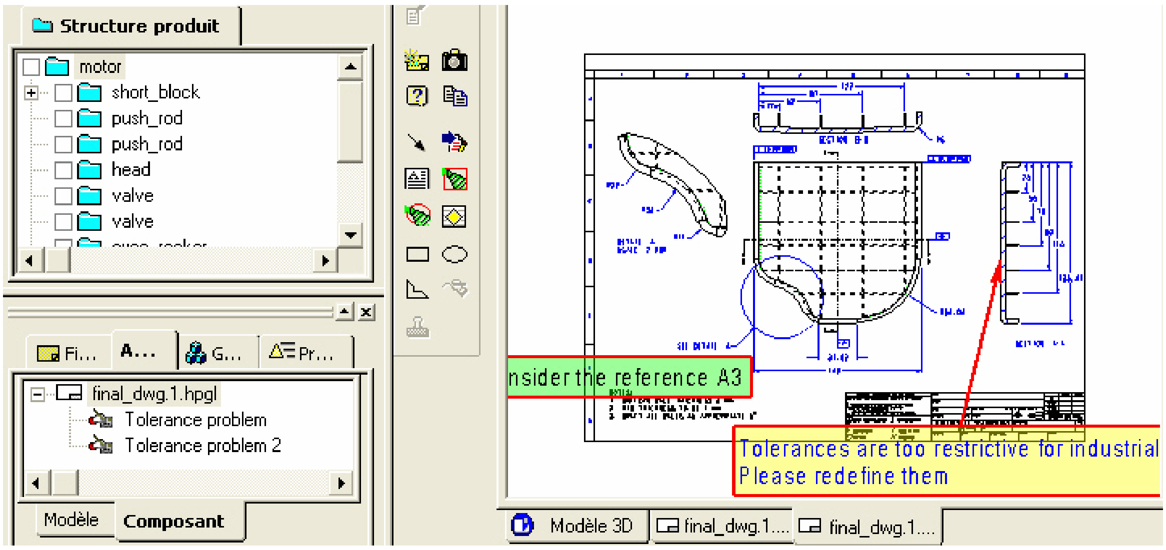


Figure 1. Annotations management for 2D drawings.

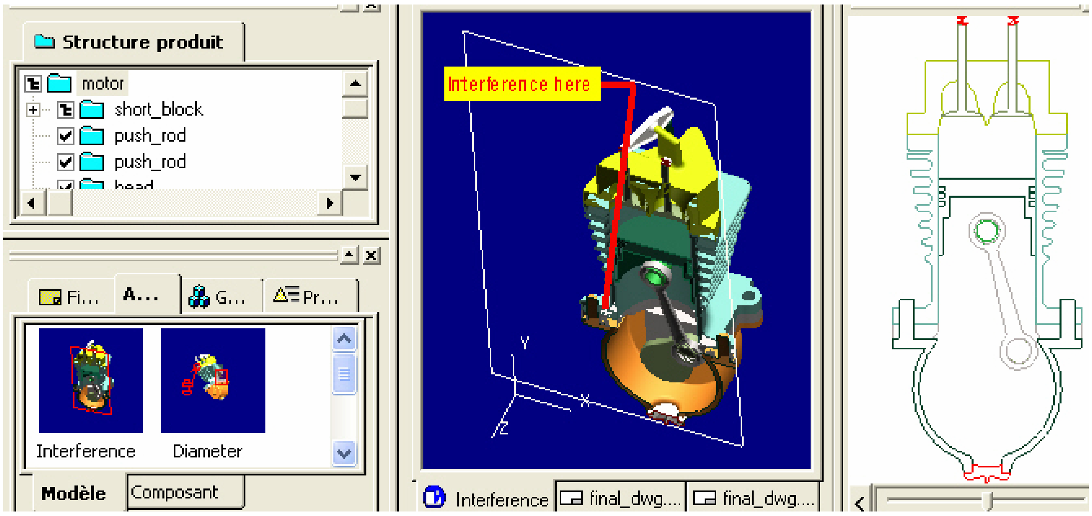


Figure 2. Annotations management on 3D models.

2.3 Results of the experiment

The configuration of the PDM system coupled with a guideline of the collaborative tool functions allows the execution of the validation process and the storage of the annotations of all involved actors. The validation process main objective is to allow actors to identify possible modifications during first phases of the design project. The proposed solution meets this objective: each annotation is stored individually. Nevertheless the information contained inside an annotation is not managed. So the collaboration between actors highly depends on their motivation and on their interest as well on their follow-up of the guidelines. The main characteristic of this validation process is that the collaboration is co-ordinated by a predefined workflow. After having explained the context of this project we now introduce another case study where collaboration cannot be predefined.

3 Fostering innovation through viewpoints confrontation and annotations

The second work we propose here was based on a field study we carried in the Renault truck company. At this time we had an interdisciplinary collaboration with social scientists and we applied ethnographic style research methods. For over 18 months we took part in the development of a new application using a composite material which was not very well known and seldom used at that time in the design office we were observing. This socio-technical study was the opportunity to closely observe the practices of actors faced with a proposal for an innovative technical solution. We were thus able to observe and characterize the difficulties involved in integrating a material, different from the ones traditionally used, in a context where the actors did not produce a minimum of shared knowledge. We were able to extend our field study to include the material department of our partner by following and questioning specific actors, referred to as “materials experts” who were also in charge of putting forward new product/process alternatives to the design offices.

This second study enabled us to precisely characterize the question of innovation during the pre-design stage [10]. In innovation situations, the goal of design work above all consists in managing a certain amount of tension between a “qualification” (or acceptance) system linked to the new materials set up by the promoters of a new solution, and a “de-qualification” (or rejection) system implemented by the promoters of a more routine-based solution. The innovation is the result of an adaptation process, the success of which depends on the actors who will be progressively involved in the design procedure [2]. In that case, the goal is therefore to organise the emergence and the confrontation of viewpoints and interactions on the new product.

In this paper we want to go further in this way because we think that innovative design process entails new tool functionalities to foster actor's networking and viewpoints confrontations. In the context of pre-design phase, actors discuss of new ideas, drafts of solutions and exchange preliminary information that may be non validated, incomplete, uncertain and ambiguous [4]. This information is partially true, and has to be updated often. The nature of information is then different from the validation process presented before in section 2. According to [7], many companies had first located design team in large office dedicated to the project to facilitate exchanges. These exchanges are mainly performed verbally face-to-face or on the phone or by e-mail. Information is therefore poorly controlled, the sharing is not really managed and there is no capitalisation of problems treated during the design. In this situation we think that annotations can help to structure design activities and collective cognitive processes. They are used to clarify and compare opposing or convergent points of view, thereby creating a meaning that can be understood by everyone.

However, we think as [7] that actual PDM systems had been mostly designed for predefined design process and well-structured information. We propose to see in the following section how the preliminary and unstructured information can be integrated in a PDM system and another specific system through the concept of annotation.

4 Collaborative tools dedicated to annotations management

4.1 Proposed approach for information structuring

According to the analyses realised within Renault truck company, we propose here collaborative tool functionalities. Some works have been done concerning the realisation and the capitalisation of a shared co-construction of the product during a design project with all the actors involved in the development of a product [16]. Actors need existing information about the searched solution such as used materials, dimensioning. But they also intend to retrieve information about the early phases of the design project such as the history of the decisions criteria, the initial context of the project or the design alternatives [9].

The collaborative tool needed must help the 'material expert' to develop its strategy for promoting a product/process innovation. So the environment must be based on the concept of an "innovation project" and it must structure the collaboration of the involved actors through the formalisation of the information exchanged. The proposed approach is based on the classification of product information exchanged between actors for innovative material validation. This classification is first composed of the three following elements: "concepts" representing the possible solutions of a material and its related process; "criteria" which allow concepts evaluation, and the resulting "evaluations". The classification is also composed of three kinds of annotation: "warnings", "questions" and "links" which structure and store the discussion between actors.

4.2 Proposed solution based on Product View tool

The use of Product View can be an interesting solution for a company in the way that it is an existing solution. It can be configured in the same way as in the first case study. The project is centred on the evaluation of concepts and criteria. They can be represented as a table, e.g. stored in an Excel file. Links, warnings and questions can be then managed as annotations on this table.

Within Windchill a virtual document is managed, and its graphical representation is associated inside Product View to the table file. The use of a virtual document is necessary because we need to store annotations even if the initial table is modified. The material expert must associate each modified table file with a different name, as shown in figure 3 (left).

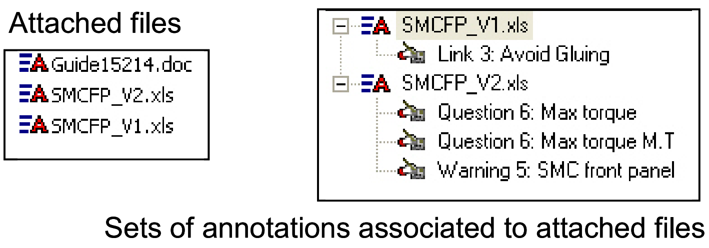
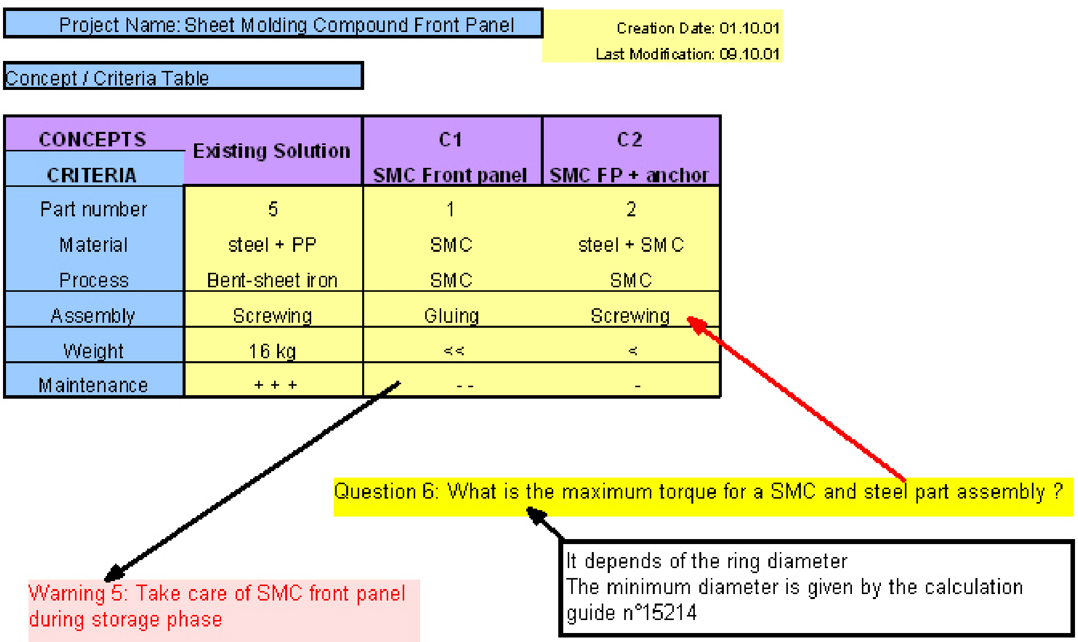


Figure 3. Annotations management within Product View.

The material expert defines his team in order to allow designers to introduce annotations in the graphical model of the table. The given name must indicate the type of the annotation (figure 3, right). But when designers propose new evaluations or new concepts they must sent them to the expert material with a different tool (e.g. e-mail) in order he can defines a new table version. Figure 4 illustrates how annotations are used.



CONCEPTS / CRITERIA	Existing Solution	C1 SMC Front panel	C2 SMC FP + anchor
Part number	5	1	2
Material	steel + PP	SMC	steel + SMC
Process	Bent-sheet iron	SMC	SMC
Assembly	Screwing	Gluing	Screwing
Weight	16 kg	<<	<
Maintenance	+ + +	- -	-

Figure 4. The "Warning annotation", based on the original table and previous annotations.

The use of Product View to support collaboration between actors in the case of an "innovation process" is possible. Nevertheless this process and the information structure are more complex than in the first case study. The objectives are also different: it is necessary not only to store annotations but above all to structure knowledge and to capitalise information for future projects. It is impossible to distinguish a warning, a link and a question within Product View. It is also impossible to establish a process which integrates in the same environment the proposal of evaluations and concepts by designers. And the stored information for future projects is not easily re-usable to improve actors' skills. These limitations can be solved by a specific collaborative tool dedicated to this case study.

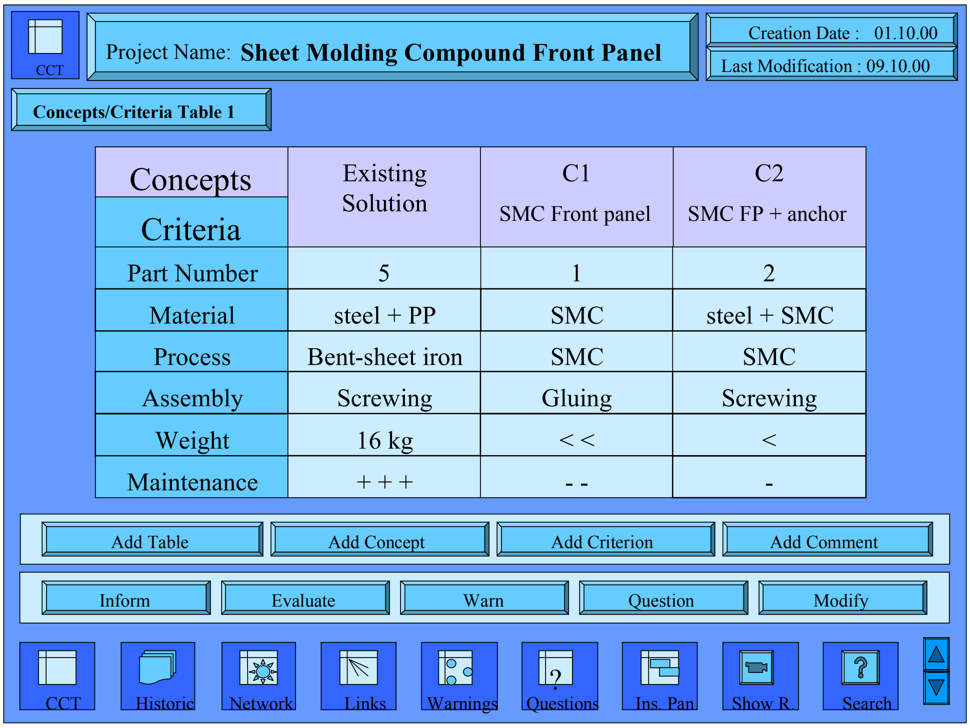
4.3 A specific collaborative tool dedicated to annotations for innovation

A specific collaborative tool called ID² [11] has been developed to improve the collaboration between actors involved in an innovation project. ID² proposes four kinds of functionalities:

- the characterisation of a panel of the project synthesising concepts and criteria,
- the formalisation of a network between actors involved in this innovation,
- the annotation of the proposed solutions which allows the storage of arguments for or against each concept or evaluation;,
- the capitalisation of stored information to improve actors' apprenticeship.

4.3.1 Characterisation of the project panel

In ID² information coming from the different domains of skills or jobs (design, marketing, industrialisation…) are formalised through a dynamic table called "Concept/Criteria Table" (CCT - Figure 5). The table shows a synthesis of all evaluations realised by the actors.



Concepts / Criteria	Existing Solution	C1 SMC Front panel	C2 SMC FP + anchor
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Assembly	Screwing	Gluing	Screwing
Weight	16 kg	< <	<
Maintenance	+ + +	- -	-

Figure 5. An example of CCT for a "Composite project".

4.3.2 Formalisation of a network of actors

The material expert defines the network of involved actors according to his strategic and technical objectives in order to promote his proposal of a material innovation. Then the tool allows each actor to describe his skills and interest centres. During a project each evaluation or annotation is stored with its author's name, in order to know exactly who is doing what. By this way each actor is able to learn more about someone and to establish new relations with him. Finally actors can access to the information through the CCT (pulled information) or by subscriptions in order to receive new information by mail (pushed information).

4.3.3 Annotations in ID²

The CCT proposes a multi-view support where each actor can react, comment and ask explanations about every point of the project. Such exchanges are formalised within the tool using four kinds of annotations (Figure 6): "questions", "warnings", "links" and "information enquiries". Questions correspond to a need of information upon a criteria or an evaluation: they illustrate the uncertainty of a solution. They are composed of sets of sentences storing the initial questions and the different answers of actors. Warnings are similar as questions, except that they represent arguments for or against an evaluation or a concept. Links are made between two criteria or two evaluations to establish a correlation: this is useful to manage modifications upon one of them. The information enquiries allow actors to express their interest in a specific point of the project. Each actor involved can propose any annotation. The material expert validates it before it is published on the CCT and stored for the project history.

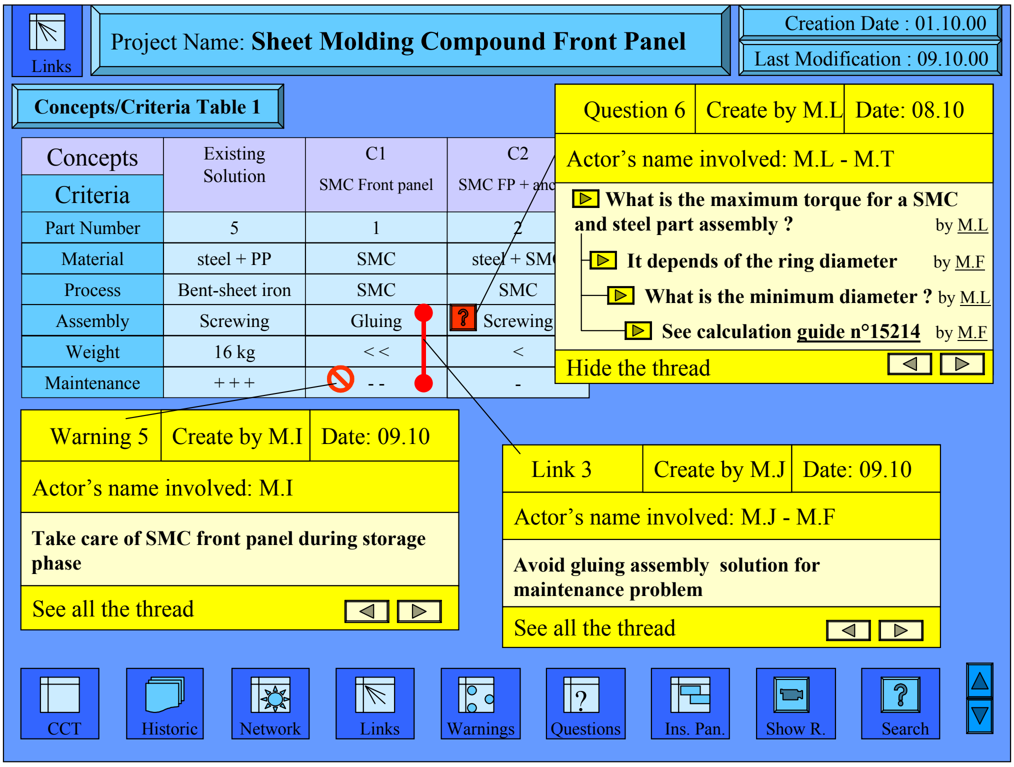

Figure 6. Examples of question, warning and link.

4.3.4 Capitalisation and re-use

First the proposed information structure leads the actors to formalise and to detail their own criteria in order to establish a collective evaluation of the innovation. The level of this formalisation and of its dissemination is very important for a better re-use in future innovation projects. Second the tool stores all the key arguments and the context which has leaded to technical choices during the project. We think that the storage of the history of all evaluations and annotations improve co-operation between actors and learning of each actor in a design situation. Third the capitalisation of information and author allows someone to locate and to retrieve more easily a researched skill or possible knowledge sources. During the project, the capitalisation allows the material expert to establish a synthesis of all the arguments and evaluations justifying the introduction of his proposal into new products. Then he can present it to engineers who develop new products.

4.3.5 Results of ID² experiment

The tool is structured to encourage actors to formulate and explain their own criteria thus facilitating discussion within the network. ID² stores, classifies and shares the information manipulated through the control of the material expert, who has the role of the project responsible. ID² encourages interactions between actors in order to promote the transfer of a new material from the idea of a possible solution to an industrial and validated solution. The design rationale of the actors involved in the innovation project is traced by the storage of actors' modifications on concepts and criteria and by the storage of their annotations.

5 Discussion

With these experiments we show that PDM tools like Windchill and Product View could be configured to be used in collaborative processes. Our results show that non-structured information can be integrated relatively in these tools with the propositions of annotation functionalities. The first proposition with Product View is more suitable for predefined processes where the goal is to propose an aided-support dedicated to the annotation expression. In this context we think that these tools are useful to promote quick exchanges among all the actors of the validation process. However the use of this tool configuration implies systematising the creation of local conventions [7] or guidelines shared by a group and that can be reused. That means it is important to allow the designers to create explicit annotations that support shared knowledge. We can imagine that they also could capitalise these annotations built in previous co-operation situation. This point constitutes elements of a learning process of co-operation within the design team. The designers have to define themselves the relevant type co-operating feature as defined by [1].

Concerning the product innovation development process our work points out the limits of PDM tools use in the specific context of non predefined and informal processes. We have seen that the design situations where partners were not sharing enough common knowledge, and more especially during the early design phases, often lead to communication and translation difficulties among the different fields of expertise and participants involved. As we saw the objectives are different: it is necessary not only to store annotations but above all to structure knowledge and to capitalise information for future projects. In the second PDM configuration, the stored information is not easily re-usable for future projects and to improve actors' skills. The different annotations are not linked to all available information and the context of use. Therefore the tool ID² is proposed as a specific development to support the non-structured information in the early design phase. This tool is structured to encourage actors to formulate and explain their own criteria, concepts, annotations, thus facilitating discussion within the network. Each new actor adds his or her vision of the solution, which may be positive, neutral or negative, resulting in a certain number of assessment criteria.

However, this tool presents two kind of limit. The first is concerning the technical integration of a specific and experimental tool within a company which can be equipped already with a PDM tool. In this situation it could be easier for such a company to configure its PDM as we see before in order to propose an integrated working environment. The second limit is concerning the corporate culture evolution required by ID² use as the tool provides a support for the stand-alone creation of informal (and sometimes non-official) networks of actors.

Subsequently we want to go further by studying the functionalities of others PDM tools in order to propose an integrated configuration which meets the requirement of non predefined design process.

6 Conclusion

In this paper we have introduced the problem of semi-structured information management during collaborative design processes. Depending on the characteristics of the collaboration different tools can be used to help designers. In a first case study a predefined validation process can be managed through a PDM system. The integration of a collaborative tool within this PDM allows the actors involved in the validation process to generate and store annotations that will lead to modifications of the studied product. A second case study deals with informal collaboration in the early phases of design projects: a material expert needs to collaborate with designers to evaluate the introduction of a new material as a possible solution for future products. This innovative process cannot be supported by the same kind of solutions because the activities of the actors cannot be predefined and because long-term capitalisation is a main objective for the company. So a specific collaborative called ID² has been developed and experimented. In future work we intend to extend the evaluation of existing PDM systems and especially to study their new project management functionalities.

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