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INTEGRATING AN EXPERT USER IN THE DESIGN PROCESS: HOW TO MAKE OUT SURGEON NEEDS DURING NEW SURGICAL INSTRUMENT DESIGN CASE STUDY

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ABSTRACT

Numerous design methods exist concerning user integration in the design process, but there is no focus or special attention on users type. The main importance of user in "user-depended design" is to provide the better understanding of user and user's needs. Moreover, the integration procedure of the user in design may change from one type to another depending on product type. In this paper we will focus on a type we call "expert user", and will try to observe this expert user in design process, in order to understand and analyze his/her needs, behavior, and interaction. As a case, the collaboration of two surgeons in a new surgical instrument design is studied, using scenario-based approach. Some points are exploited and the eventual influences on the design are discussed.

KEYWORDS

User-centred design (UCD), design collaboration, surgical instrument

1. INTRODUCTION

Most of design studies concerning user needs have been based on novices or, at best, accessible users of relatively modest talents (Besnard, Bastien-Toniazzo, 1999). The reason is, some how obvious, that it is easier to obtain such people as subjects of study and they seem to be good enough. If studies of users needs are limited to studies of rather inexpert users, then it is also obvious that the resulted understanding of expertise use will also be limited. Moreover, in design of new high-tech products the role and importance of professional user is no longer negligible. From research point of view, the integration of user himself in design process is different from considering user's needs and requirements by existing methods. In some instances, it will be necessary to study out standing, or exceptionally good users. In this research we have chosen the surgeon as an expert user in design process of innovative surgical instrument, in order to gain insight of the cognitive interaction and the nature of expertise in design process.

The aim of the article is to show that in user depended design processes, an expert user should be considered and integrated in a different manner from a general user. To follow this claim, the article starts with a detailed review on existing researches of user integration in the product development process, known generally as User-Centred Design (UCD). This section finishes with explanation of the drawbacks of existing methods. Section 3 answers the question why an expert user should be considered differently. Section 4 describes the methodology of our researches and the case study. Section 5 addresses main points of the experiment. The article ends with the lesson learned and propositions.

2. USER AND THE DESIGN PROCESS

The purpose of the research behind this article is to find the position and the effects of user in design process, particularly when the user is an expert and the design is highly dealing with his expertise. As it will be seen in the case study, developing an innovative

surgical instrument is selected to study the characterization elements of expert user and his effect on the design process. Taking surgeon as an expert for granted, surgical domain has been selected because of its increasing need for innovative instruments in order to performing new operations. As the medical profession is faced with demands for grater accountability and patent safety, there is a critical need for the development of consistent and reliable methods for objective evaluation of clinician performance during procedure. There are numerous different aspects to consider user needs - surgeon in this context - like the approaches for modelling and analysing a surgical procedure, measuring gesture and movements of the surgeon, and virtual reality simulation for the operating room.

Several comprehensive user related design methodologies have been published in the last decade, like UCD and Participatory Design (PD) (see section 2.1 and 2.2), but while they all focus on users, they disagree on the definition of user, what relation exists between user and product, what activities should take place during the user needs analysis, and how these finding should be observed, presented, documented and communicated. All these aspects assume that the user's knowledge, capabilities, limitation and needs have to be taken into account. Moreover, there is the actual use situation and environment that has a great effect when the degree of expertise of user increases. The usability of a surgical instrument could not be evaluated out of operation room and without real constraints.

2.1. User-centred design

One of the cornerstones theories about user involvement is User-Centred Design (UCD). UCD as a design approach was introduced first time in the format of the standard ISO 13407: Human-Centred Design Processes for Interactive Systems (ISO13407 1999). The idea of developing usable products and services always pushed the design approaches toward placing the user in the design process. There exist many literatures on UCD, called also Human-centred design and usability design with the same basic principles for develop products and services that will meet the needs and expectations of the end users by user involvement such as iterative design and multidisciplinary teamwork (Hix, Hartson, 1993; Nielsen, 1993; Holtzblatt, Beyer, 1998; Mayhew, 1999). The main issue is how to involve and integrate the user in the design process.

The general reference model of UCD principles and process is the model presented by ISO 13407 (Johnson, Healey et al., 2006). It identifies five UCD activities, one main for laying out the design process and the four rest of which deal with the substance. The four UCD substance processes are illustrated in Figure 1:

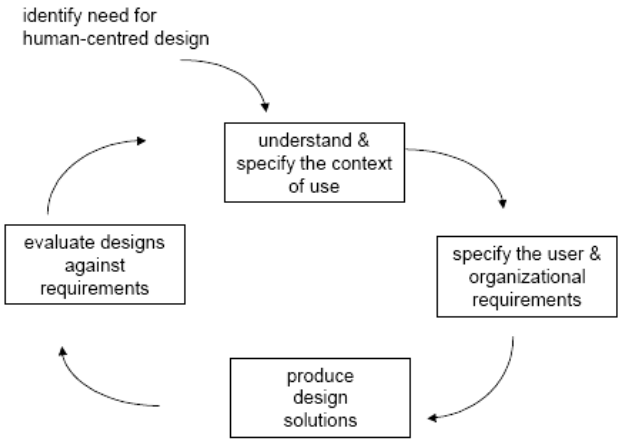

Figure 1 Processes for user-centred design in ISO 13407

To understand and specify the context of use, the characterisations of users, the tasks and the environment (physical and organisational) should be identify in detail. For the potential user the characteristic includes knowledge, competency, experience, education, training, physical characters, habits, preferences and aptitudes. For the consigned tasks, the description of sensitive and responsive affect on usability such as frequency and running time is necessary. And, the environment contains material elements, softwares, and employed products.

The process of specify the user and organizational requirements distinguishes an explicit statement of user and organizational requirements in relation to the context of use description. Despite of the ambiguity of definition of process in this step, there some considerations in order to identify relevant requirement, such as required performance of the new system against operational and financial objectives, co-operation and communication between users and other relevant parties, management of change including training and personnel to be involved.

The process it self is expressed further, with specification in software and not as a procedural form. Some of these notifications are:

"a) Identify the range of relevant users and other personnel in the design;

b) Provide a clear statement of the human-centred design goals;

c) Set appropriate priorities for the different requirements;

d) Provide measurable criteria against which the emerging design can be tested;
…"

The Produce design solutions process is about producing "potential design solutions … by drawing on the established state of the art, the experience and knowledge of the participants and the results of the context of use analysis"; and the Evaluate designs against requirements process is "an essential step in human-centred design and should take place at all stages in the system life cycle".

Although the ISO 13407 describes each process in detail, it takes an informal way. It is not clear that how a process defined by sub-sequences and is it just between to phases or also in one phase. This ambiguity encourages the researchers to meet the formality of process definitions set which ends to development of ISO 18529, Human-Centred Lifecycle Process Description, approved as a technical report of ISO in 2000. (ISO18529 2000)

As mentioned above as the main issue, the details in integrating the user in design process are very interesting in research point of view. Some researchers have proposed a novel process model of UCD, contrasted it with existing models, and reported their experience of using the model; see Jokela in (Jokela, 2002a). The original aim of these kinds of researches is to learn how to improve the performance of UCD processes of product or system development trough the amelioration of user interaction with the process. We describe Jokela's model further and give some comments about.

The main idea of Jokela's new UCD process model is to intercommunicate the user with the usability in cycling process, as shown in the schema. "User interaction" as he defined, aims to produce the interaction between user and design process who leads to four outcomes: user training assets, user documentation, product package and user interface. On the other hand, this model supposed to be an effective tool for training in the essentials of UCD. Some feedbacks indicate that getting needs piled up is more practical than focusing on methods (Jokela, 2002a). He has also worked on Method-independent process model of UCD (Jokela, 2002b). He identifies six main processes of UCD, each is defined through a set of outcomes.

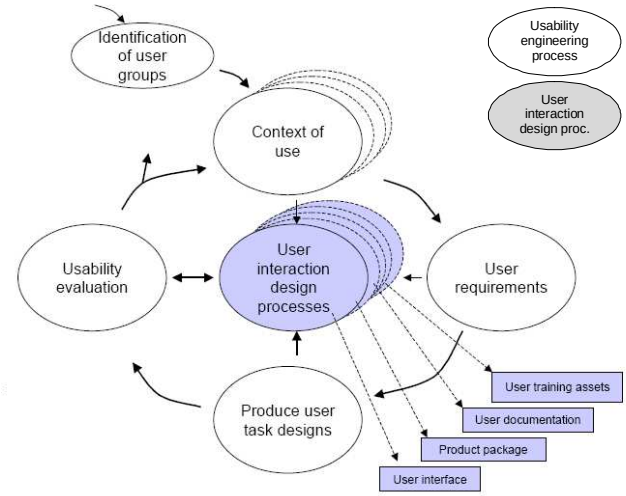

Figure 2 Jokela's UCD Process Model

The other important issue in UCD is how identifying and selecting relevant users in the development work. In practice it is commonly possible to involve only a limited number of users, and therefore it is very important how to select the "representative users" to centre the design on their requirements and expectations. There are several studies in different themes such as (Carr-Chellman, Cuyar et al., 1998), (Bekker, Long, 2000), (Wilson, Bekker et al., 1997), trying to avoid misunderstanding the representative needs.

Are the users like us? In many situations designers have a vague sense of their intended users and may base scenarios on people similar to themselves (Kujala, Mäntylä, 2000). Persona, as Cooper suggests in (Cooper, 1999) is a substitute of a hypothetical user and his goals and needs. This will help to define the product by replacing the notion of the abstract elastic user. Indeed, persona gathers detailed descriptions of a typical user.

Kujala and Kauppinen propose a process of identifying and selecting users, based on existing approaches for gathering user needs by field studies (Kujala, Kauppinen, 2004). Their findings support the view of several authors that varied kind of users should be selected in UCD (Wilson, Bekker et al., 1997; Hackos and Redish 1998; Holtzblatt and Beyer 1998). They clearly pointed out by their seven case studies that focusing on just one person or user group in not reasonable.

On the other hand, the importance of user selecting is totally dependent on the context of product design.

Despite of all consideration about user selection, they mentioned that in most cases, user needs do not vary a great deal; in fact, a core set of common needs can be identified. (Kujala, Kauppinen, 2004)

User satisfaction and acceptance, as an important design factor, may not always be dependent on the usability of the product. Jokela reason out this non-rigid unpredictable expects: Sometimes users do not mind even major usability problems; in other cases usability problems may lead to severe user dissatisfaction. In some cases it might be necessary to include all the features in the product that the user hopes for, in order to avoid user dissatisfaction and to gain user acceptance (Jokela, 2004).

2.2. Participatory design and user design

The two other important theories which are developed under consideration of stakeholder involvement is what has been called participatory- or user design. Some people believe that they are the same (Carr-Chellman, Cuyar et al., 1998), but they are mentioned separately in the literatures. While the value of including the users is apparent, the reality of such efforts has a history of failure and under achievement in Nordic European countries. User-Design stems from the traditions in Scandinavian software design and has recently been described for purposes of thinking about the design of instruction, training and systems of human performance (Carr, 1997). User-design attempts to extend stakeholder involvement beyond input and reflection on product design and instead to create empowered users who have true and substantial decision-making powers. The approach in which stakeholders are more than just ”involved” in change and design is often referred to as User-Design in systemic change theorists’ language (Banathy, 1991; Reigeluth, 1993; Jenlink, 1995).

Very similar and almost the same research began in the mid 1970’s in reaction to the ways in which computer-based systems were introduced in the workplace and to the deleterious effects these systems were having on workers (dislocations, deskilling, etc.). The introduction of computers at work was seen as central to a growing debate in Scandinavia and Germany about the place of industrial democracy in modern workplaces and the methodology named Participatory Design.

Kensing (Kensing, 1983) outlined three basic requirements for participation reiterated from the review of ten PD projects done by Clement and Van den Besselar (Clement, Besselaar, 1993). 1) Access to relevant information, 2) The possibility for taking an independent position on the problems, and 3) Participation in decision making.

The participation of the intended users in technology design is seen as one of the preconditions for good design. PD researchers hold that design professionals need knowledge of the actual use context and workers need knowledge of possible technological options. We will talk about this point in detail.

The final point to be mentioned is participatory methods had some efforts from product developers to adapt and extend elements of the participatory design approach. Some of these issues are mentioned by Grudin and Pruitt as low-fidelity mock-ups and prototyping, increased engagement and communication with potential users, and an emphasis on site visits and understanding the work context (Grudin, Pruitt, 2002).

2.3. Summary and wind up

Understanding the specific ways in which designers can enable end-user to take a decision-making role in the design of his eventual product or system is an important step toward effective implementation of technology and educational practices. This issue has the both advantages and disadvantages in design progress. However, little research exists around user-design to date, and no strong evidence is offered for use by training, instructional design, or systems designers (Carr-Chellman, Cuyar et al., 1998). It is important to be mentioned here, to distinguish this work from these traditional and well-researched areas of UCD, user design, and participatory design in Human Computer Interaction literatures. While a good deal of work exists on the involvement of users as advisors to expert designers, and on the testing of new products with end-users in marketing studies, these represent more traditional understandings of the role of users than we are advocating here. We put emphasize on knowledge, capability, expediency and ability of user, we call expertise, and we focus on the effect of user expertise on different phases of conceptual design.

3. WHY THE EXPERTS SHOULD BE CONSIDERED DIFFERENTLY?

The concepts of experts and expertise are debated within the field of epistemology under the general heading of expert knowledge. In contrast, the opposite of a specialist would be a generalist, somebody

with expertise in many fields. The word experience means direct observation of or participation in events as a basis of knowledge and the fact or state of having been affected by or gained knowledge through direct observation or participation (Merriam-Webster). Expert is the person who supposed to have the experience. The knowledge is the main issue that considered to the representation of user. Also, expertise reduces information processing load and allows the expert to cope with a possible increase (Bisseret, 1970). For many years, researchers tried to integrate the knowledge of user in design process as a representative of him, neglecting many details. But once user is an expert, the whole idea of integrating knowledge will be on incertitude.

When designers design for a use situation, they usually put themselves in the role of the user (Buur, 1993). A designer or an engineer is rarely representative for the user, and is invalid when the user is an expert with professional knowledge. It is also necessary to give more attention in user cognitive ability as the key element in information processing. According to the studies of user background effect on evaluation of a medical prototype interface, when more ergonomic factors are included in defining the user background, more design flaws might be detectable and a wide range of error detection could be achieved (Liu, 2004). In this way the definition and interpretation of knowledge should be discussed.

We suppose knowledge, as emphasize Chevallard in (Chevallard, 1991) personal and belonging to an individual. Prudhomme et al divide knowledge to knowledge object and knowledge relation.: "An object of knowledge exists if it exists for a person or an institution. It can be of different natures: material or symbolic.[...] When an individual interacts with a knowledge object in a given context, he or she will create a personal relation with the object." (Prudhomme, Pourroy et al., 2007)

In accord with this idea, we can explain the expertise more clear in thought of personal relation. What has a important role in integrating user in the design process is to integrate this aspect of user knowledge, which could not be found without integrating user and providing the process regarding the type of this integration.

3.1. Observing expert user

Some observations indicated that experts have effective means for enhancing the desired task. There is a known French approach in cognitive psychology about observable behaviours. André Bisseret explained in his book some practical techniques for studying the expert activities (Bisseret, Sebillotte et al., 1999). The hypothesis of this work is that knowledge is different from representation, and by the term knowledge is a structure in care of a subject and may be true or false. The representation is an interpretation of a particular situation: "Representation is mental and central. The expert interprets the situations where he intervenes, based on his objective and his knowledge in order to endeavour an action."

- Three main description of representation used in this book, and we also used in our observation are:
- Presenting just necessary information which is used by the expert in his activity in real.
- Choosing a coding mode on favour for each type of information
- Optimizing the spatial positions relative to information, considering relative importance.

3.2. Expertise and experience

User experience used to describe the overall experience a user has when using a product or a system. The user experience research focuses on the interactions between people and products/services, and the experience resulting from the interaction. To make use of user experience in design development, we should define what we exactly called experience, and what it contains. The experience of even simple artefacts does not exist in a vacuum but, rather, in dynamic relationship with other people, places and objects (Buchenau, Fulton Suri, 2000). Defining the user experience can extend to concern all aspects of experiencing the product or service, including physical, sensitive, cognitive, emotional, and aesthetic relations (Kuniavsky, 2003). User experience strengthens the role of time, context, meaning and emotions in using products or services. Also shared experiences (e.g. coexperience, (Battarbee, 2004)) and social interaction are lately taken into the discussion (Leikas, Strömberg, 2005; Leikas, Strömberg et al., 2006).

There is some studies about experts problem-solving performances and equated to the novice. In spite of all have done in studying experts, there is a hypothesis that, under some conditions, novices may develop a more efficient diagnostic reasoning than experts. (Besnard, Bastien-Toniazzo, 1999) showed that novices perform better than experts. This hypothesis mainly relies on the possibility that experts may be victims of their own knowledge format

(French, Sternberg, manuscript). More over, Lesgold et al (1988) showed that expert radiologists may produce less intense diagnoses than resident radiologists (Lesgold, Glaser et al., 1988). The authors concluded that expertise is not a monotonic function of experience. It builds itself via fluctuations in the performance levels. Although these studies are not in design phase, but we would comment on the proposed perspective of difference of expertise and experience in experts work.

And for the last word, we mention that Non-methodological experts (Dobrow, Goel et al., 2006) often had a simplistic understanding of evidence hierarchies, reflecting a categorical distinction, based on study design, between experimental and non-experimental evidence.

3.3. Why these studies matter?

In all of discussions above, the attention to the user is recognised and developed in HCI sciences and software and electronic appliances engineering and design. In mechanical production, the theories never cared about the user as a persona with his proper needs and expects. There are many reasons for that, but by the time and huge development in interdisciplinary fields, such a strict design process model could not answer the new collaborative needs. As we will describe further, some mechanical design process should be take the challenge of change. On the main entry as we supposed in this paper is the expert user.

4. RESEARCH METHODOLOGY

We chose a co-evolutive approach for describing the development process. New instrument development is parallel to new application maturation. This methodology is described in detail in (Rasoulifar, Thomann et al., 2007). Figure 3 shows a schematic view of this methodology.

The main advantage of the UCD approach is to make a deeper understanding of the psychological, organizational, social and ergonomic factors that affect the use, but we still need some intermediates to identify, capture, and analyze these inputs understanding from the user. For this reason and to avoid the case of a too specific tool, we decided to experiment the Scenario-Based Design methodology (SBD).

As we will discuss later, there are several aspects of each surgical instrument that should be verified by surgeon. To understand the use situation (surgical

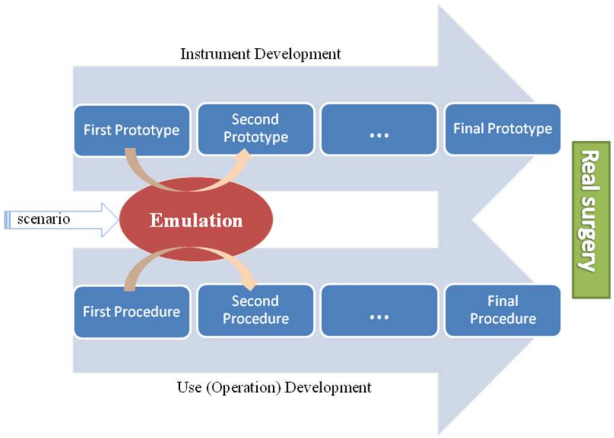

Figure 3 Evolution of the Prototype and the Surgical Procedure versions on the proposed Co-Evolutive model

operation) we have prepared a scenario which describes the procedures and goals. Based on that scenario, we design an instrument and after basic validation with the surgeon, we made the first prototype. But the main issue is a surgical instrument can not be evaluated out of use condition. More over, the surgeon needs to manipulate the instrument in operating bloc and on a suitable mannequin. So, in order to verify prototypes function and understand user needs during the use, we prepared a simulation of a real lumbar arthrodesis surgery which we called emulation.

The SBD allows designers to create new tools and devices with user participation during all the primary phases of the design process. Many papers deal with the advantages of the SBD and with the way of creating scenarios (Rosson, Carroll, 2002). In SBD, descriptions of situations become more than just orienting examples and background data, they become first-class design objects. Scenario-based design takes literally the adage that a tool is what people can do with it the consequences it has for them and for their activities that use it.

In SBD, scenarios of established work practice are constructed. Each scenario depicts actors, goals, supporting tools and other artifacts, and a sequence of thoughts, actions, and events, through which goals are achieved, transformed, obstructed, and/or abandoned. The scenarios are iteratively analyzed, revised, and refined (Thomann, Caelen, 2007).

We prepared a data collection form in order to bring together all the possible information from observation in the operating bloc (see (Rasoulifar, Thomann

Figure 4 The surgeon is using the first prototype during the first emulation in real operational environment

et al., 2007)). There are four steps of data collecting: First, before the operation: asking the surgeon to explain successive objectives of the operation. Second: during the operation with the prototype, we asked him to describe what he does and his complement about the prototype. Both of his act and voice were recorded with two different cameras, one established on his head for recording what he is watching. Third: just after the operation, we asked him to summarize his operation and point-out advantages and disadvantages. The forth step: some days after, he watched the film of operation and rexplained what he did. In the same time, the filled part of form was verified with the surgeon.

To prepare a scenario, it seems to be necessary to write the story in a simple language. In detail of user-instrument interaction, it is also important to leave some references in surgery and in engineering, except when it becomes complicated. We made the scenario read by the user to be sure that it is representative of the real world in which he evolves. In agreement with the surgeon, scenario was decided to begin not from the beginning of whole operation, but from a certain stage of established operational procedure.

To recover a maximum of information at the end of this experiment, instructions were clearly notified to the surgeon. Frontal and general video cameras and a micro tie were installed to clearly observe the user and record its remarks.

Based on our methodology, we prepared first prototype and first scenario to start first emulation. The experimentation took place at Orthopedic service, Grenoble Hospital. The whole operation was filmed as explained and gathered data analyzed in order to understand functionality and efficiency of the prototype.

As we discussed before, not only the instrument should be evaluated and modified, but also the surgical procedure - as it is innovative - should be tested and validated. For this reason we asked the surgeon to describe what he does during the operation and also to give his comment on the instrument, like critics, problems or propositions.

Based on first emulation and captured data, some modifications were performed on the prototype and protocol and the second scenario was made. For the second emulation we used another surgeon. The idea was to have a comparison between two expert users in similar operation. On the other hand, more lately we asked the first surgeon to look the operation done by his colleague and enplane what did he do and also why.

Finally, on the same way the third emulation organized by a more pertinent prototype and enough developed protocol. After this stage and by satisfaction of both sides, the conceptual design was finished and the product entered the detail design and patent issue.

5. CASE APPLICATION AND INTEGRATION OF USER EXPERTISE

5.1. Application: MIS in lumbar arthrodesis

To better understand the present discourse it is often useful to consider its background. This story begins with the innovative idea of a surgeon for amelioration of open surgery and to turn it to the Minimally Invasive Surgery (MIS) operation.

MIS is a new kind of surgery in which the operation perform trough a small incision and surgeon avoids cutting the mussels, even rarely separates them. So the patient has less pain, less bleeding and will recover quicker. In comparison to the usual, open surgery, MIS operations are better for the patient, but harder for the surgeon and they need some special instruments.

In the design of medical appliance, health care and robo-surgical device, particularly for new operations, there is a communication and co-operation between designer and customer (often end user), and there has been an increased interest in participatory design and

in designing aided by scenario. The interest in participatory design cans be seen as both an effort to develop a new technical solution for a conventional use (e.g. new mechanically developed instrument for a common surgery), as well as an innovative idea of user for improve the use which need some new tools (e.g. a surgeon who propose a new operation). As such, this represents an important development in many ways and by introducing new aspect of user integration, it can support affording a rich design process.

The aim of studying the design process is to identify the appearance of user as an expert in the process and his/her relation with the designer. The goal of the case study is to recognize the characteristics of this interaction.

5.2. Description of the operation

In this specific surgical operation, a particular lumbar fracture is caused by 50% of the serious sport accidents (falls of motorbike, ski, and parapet, etc.). Currently, the ”classical” lumbar arthrodesis operation is consist of following steps: make a 25cm incision on patient’s back, put 6 screws on three vertebras (the fractured and its neighbors), insert two rods in screw’s head and fixing them. Figure 5 shows the final position of rods and screws.

The idea is to avoid the grand incision by passing rods through a needlepoint incision and manipulate it to enter three tulips (screw’s head) on a straight line. The screws should be placed separately by a known procedure using an instrument named Canon.

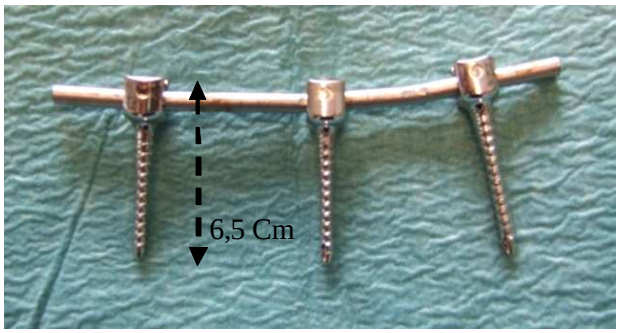

Figure 5 Picture of one part of the current implant placed on the lumbar vertebra of the patient

The difficulty rises on the fact that without the large incision, there is no visibility inside during this new established operative procedure. The precise placement of the holes (located compared to the vertebrae) depends of the knowledge and the experience of the surgeon. The delicate insertion of the screws through the skin, muscles and grease, without damages caused to the patient, requires the design of complementary surgical tools.

5.3. Surgeon and conceptual design

This study shows an initial step towards understanding the importance and benefits of expert user in the early stages of product development. We try to take out the stages in out design approach where the expertise of surgeon plays a role in progress. As explained in section 4, in this research two surgeons were integrated into the conceptual design phase, and in different stag, the confrontation between them and engineers was recorded and analyzed.

The target instrument actually is in detail design phase and final validation n cadaver, so the technical data can not be published. However, the aim of this article is not to propose a new instrument in surgery, but to propose and discuss the idea of integrating the surgeon – as an expert - in the design process. In paragraphs below, we discuss four stage of expert user integration and we comment on its effect on product development.

Preparing the scenario

The first scenario was prepared based on the surgeon description of new surgical operation. The main exigencies of instrument, the principal steps of the operation and also some medical details about the organ that should be take into account while design of new instrument were discussed in the reunion with both of two surgeons.

Scenario was modified after each emulation scenario as the prototype was being improved and surgical protocol also, to become more similar to the real operation. The operational particular techniques came from surgeon’s point of view.

Emulation

In the emulation the surgeon manipulate the prototype on a mannequin on the radio-translucent table in operating room. The surgeon verified functions and usability of the prototype during the operational tasks. Mechanical forces, movements, ergonomic factor and so on were discussed with him during the emulation stage. The surgical gesture is a good example of professional knowledge of the surgeon. More over, the prototype should be checked to not have any incompatibilities with the other operation tools. In the case of some mismatching, like we

have in the experience, proposing the alternatives and decision making is highly dependent on surgeon's knowledge and opinion.

Observation

It is very important and difficult to observe the surgeon and what he does. Because of his unique situation just beside the patient, we can not exactly see his hands movements. More over, the operation is MIS and he guide him self by taking radio images. These images are hard to recognize and very rapid to follow. After two emulations, we established the best combination: a general camera that record the whole scene, and a frontal camera placed on surgeons head for more focused view on operation location and on radio machine. Although some technical problem exists (like fast moving and some decentralized moment), but at the first look one can consider the importance of frontal camera in understanding the surgeon's action.

Verbalization

In all of emulations, the surgeon was asked to describe what he does and some how to explain why. More over, he was asked to criticize the prototype and to give his solution for problems. The fact of recording the operation helped us to review the verbalization many times in order to understand what exactly he meant. Beside of strange technical words and expression, many obvious points in surgeon's comment were explored to find the reason. Better understand of surgeons actions and desires cause to clear need list, and to more preferment design.

6. WAYS OUT AND CONCLUSION

Integration of expert user in conceptual design was proposed and studied in this article. In the case of new surgical instrument design, we tried to focus on surgeon and his interactions in conceptual phase, following the methodology of co-evolution in product and its usage. Based on some bibliography in integration of the user in design process, we tried to point out the difference between expert and general user in this collaboration. For conclusion, we would classify some characters and behavior of surgeons that may be possibly extendable to expert user.

On the other hand, we realized that despite of surgeon's interest for collaboration, it is not enough for him to simply explain his exact requirements or give his professional comments. Four stages mentioned in the last section are examples of special situation in which some effort were made in order to integrate the surgeon's expertise in design. It can be concluded that the observational aspect of this research has a significant importance.

We propose that these four stages can be used not only for conceptual design of a surgical instrument, but also more generally for all conceptual design phases which deal with an expert user who has the expertise outdoors of the engineering base of design (for example design of cabin interface of airplane).

As we could possibly point out, the experts are more or less untouchable, that means they are not accessible, they are busy most of the time, and may change regular timing to work early in the morning or late in the evening, and they can cancel a programmed reunion.

The expert's point of view is very limited and banded in his carrier. According to some authors, in a problem-solving situation experts rely on structural features (Hardiman, Dufresne et al., 1989; Smith 1992; Zajchowski, Martin, 1993), while a study shows that experts rely on surface features. There can not be a clear judgment, but, as a matter of fact such observations are highly depended on context of experimentation and, framework of analysis. By the way the hypothesis of being banned in knowledge format is seems to be valuable.

Our experience implies that experts are not shy to be observed. One of interesting points in this project was the fact that despite of many issues about difficulty of user observation, the expert user enjoys showing his expertise, to explain it and to participate in technical discussion of design. There is of course more socio-technique discussion in this issue, and it design point of view, it is important to acquire maximum possible data from user during the use emulation.

One important thing in dealing with expert user is the communication between user and designer that is suppose to be the knowledge bridge. Experts are not capable to explain what he does. One reason may be the complexity of domain, surgery for example. The other reason is the grand existing gap between two proficiency, surgery and engineering. It could be reasonable to provide some knowledge in the other domain, but actually, neither the surgeon nor the designer couldn't possibly spend much time on the learning the other domain.

Focusing on user's need or customer's need is a developed issue in conceptual design, but as we experienced, it is not clear that who is the user and who is

the customer. Depends on type of surgery and hospital's regulation, the customer could change from the patient to hospital' sales person. There is always the question of total price, and surgeon, as a matter of fact, is not the person who pays. Financial equation in medical and surgical device is not easy to understand and to manage. Such a product is often a member of product family and should not be considered as a design a unique product.

For the final point, our experience shows that it is not quite simple to have two surgeons in operation room on a prototype and a mannequin, but it really helps to understand their team work behavior and to have all possible comments and critics, in different roles.

In our future works, we will try to validate our results on different surgical design projects, in order to have more generalized procedures of integrating surgeon as an expert user in design process.

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