PRODUCT DESIGN OF NOVEL TECHNOLOGY-BASED PRODUCTS - THE IMPORTANCE OF USERS

Sampaio, Álvaro M.; Pontes, António J.
University of Minho, Portugal

Abstract

Terms such as product design, engineering design, and others, have been used to represent specific ways to look at Product Design and Development (PDD). Each of them features specific methods and techniques and, despite the evolution of PDD, most processes remain unchanged. Moreover, as products incorporate more technology, with emphasis on microelectronics, it becomes obvious that improvements of the traditional PDD processes are required. Incorporating microelectronics in products, without the user being able to perceive them, while simultaneously ensuring their functionality, is not a trivial task. Therefore, improving a user-centered design (UCD) approach is paramount. In this framework, 6 design processes proposed by different authors and the UCD standard were analysed by comparing the phases of each process, and their methods, techniques, and tools were explored. Finally, a case-study is described, which enables studying how the different processes can be applied and, how the user could be linked to the process. This opens the path for the optimization of PDD to meet the needs of novel products by improving the importance of users' direct participation in the process.

Keywords: Design process, Participatory design, User centred design

Contact:
Prof. Álvaro M. Sampaio
University of Minho
Department of Polymers engineering
Portugal
amsampaio@dep.uminho.pt

Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

The microelectronic sector represents a global market worth more than 6 trillion Euros. In the last 50 years microelectronics have flooded our daily life with a massive utilization, in areas such as health, security and more. Virtually, microelectronics appear in every aspect of human life, establishing a deeper connection with products based on new technologies.

Technology has always been an important element in the regular person's daily life, mainly in the attempt to master the world that surrounds him and in attaining its necessities in an efficient way. Although there is a dichotomy between the technological advances and the society in general, this is being modified by the mass production of industrial products. In industrial production, the inclusion of advanced technology is now prevailing in many products. All of these modifications in production are supported by the production industries' necessity in differentiating their products. In a competitive market, products need to exhibit more features and functionalities in order to obtain commercial success. In this way, novelty technology embedded in consumer products becomes the major factor of differentiation. This phenomenon has a certain impact on the end user. In the attempt to implement the latest technologies in products, interaction principles change. Product's shapes stop being the physical element of the interaction, and the way to use it shifts to a more abstract notion of use. During the mechanical era the interaction was concrete and, typically, quickly understood. The incorporation of microelectronic in products changes interaction in a drastic way. Push buttons and switches started, sometimes, to be replaced with a more intangible interaction (e.g. wireless). Therefore, user interaction becomes a central part of the development process, since users are becoming frustrated with the enormous number of features that the products have, while having a common inability to identify them. A User-Centred Design (UCD) approach becomes a need in the development of technology-driven products. A development centred in the user, in an era in which the necessities are more imposed than real, will result in a more user-friendly product. In this microelectronics world, product design and development (PDD) processes need to be adapted and better organized. In most cases, this inclusion of microelectronics requires new manufacturing methods and new technical product specifications. One paradigmatic case is the need to incorporate microelectronics into already existing products. The difficulty/impossibility of simply embedding the microelectronic device into the product, while maintaining the existing usability protocol, creates complex obstacles. For this case, a solution is to develop an add-on product that will be coupled to the original product or family of products. In this work we address this problem, specifically applied to families of existing products which require new functionalities through microelectronics.

2 REVIEW OF CURRENT PDD PROCESSES

The understanding of the several design processes and their inherent methodologies is a key point for managing the activity of PDD, in order to aid the improvement of products and the overall efficiency of companies. Thus, this section introduces a structure (Table 1) that enables establishing boundaries of the PDD, and at the same time the analysis of the common and distinct points of the overall phases of six different design processes and the UCD (ISO 13407, 1999).

In this comparison, it was just listed prescriptive models, more framed by the engineering field, for the simple reason that the aim was in getting knowledge, not just in the general models of the PDD, but more profoundly in the activities and how these activities are done. For the case of the UCD, although the standard is only a descriptive process, several methods and techniques employed in the UCD process were acknowledged.

The headings used in Table 1 demonstrate the general agreement of design authors on common - often synonymously named - phases. Of the six phases, four: 'analyses of the task', 'conceptual design', 'embodiment design' and, 'detail design' are the main phases which were established in order to describe the general PDD process. From Table 1 it is possible to observe that different names are listed for the same phase, although some phases are divided in two sequential stages (Ullman, 2002), while some phases are grouped in just one (Pugh, 1991). The only difference is seen in the ISO standard, which only exhibits phases in the development process, until the concept design phase. Nevertheless, these four phases are actually the same in all of the processes, tending to develop and reach the exact same thing. Preceding this four phases is the 'necessity' phase, where the driver for the design is recognized. In the table, one can see that just half of the listed processes fill the first phase (Pugh, 1991, Baxter, 1995, Ulrich and Eppinger, 2007). Thus, as the PDD process is driven by one or more of the following three factors (Belliveau et al. 2002), ‘Technology’, ‘Market’, ‘Management’, one can say that the ‘Market’ in this cases is the main driver in the analyzed processes, even though today’s products make an increasing use of technology and are increasing their complexity by putting more features in to a single product (Simoes and Sampaio, 2008). The main driver of today’s products is ‘technology-push’, however, although is not possible to see in the table, some of the processes (Ulrich and Eppinger, 2007, Pugh, 1991, Baxter, 1995) make reference and propose different knowledge of the PDD process in the case of the ‘technology’ factor. In other words, they present an altered process when it faces technology factors.

Table 1. Comparison of the PDD processes

<table>
<tr><th></th><th colspan="10">Phases</th></tr>
<tr><th>Models</th><th>Necessity</th><th colspan="2">Analysis of the task</th><th colspan="2">Conceptual Design</th><th>Embodiment Design</th><th>Detail Design</th><th colspan="2">Implementation</th></tr>
<tr><td>Pahl & Beitz (1999)</td><td>X</td><td colspan="2">Planning and clarification of the task</td><td colspan="2">Conceptual Design</td><td>Embodiment Design</td><td>Detail Design</td><td colspan="2">X</td></tr>
<tr><td>Pugh (1990)</td><td>Market</td><td colspan="2">Specification</td><td colspan="3">Concept Design</td><td>Detail Design</td><td>Manufacture</td><td>Sell</td></tr>
<tr><td>Baxter (1995)</td><td>Business opportunity</td><td colspan="2">Design Specification</td><td colspan="2">Concept Design</td><td>Embodiment Design</td><td>Detail Design</td><td colspan="2">Design for Manufacturing</td></tr>
<tr><td>Ulrich & Eppinger (2008)</td><td colspan="3">Planning</td><td colspan="2">Conceptual Design</td><td>System-Level Design</td><td>Detail Design</td><td>Testing and Refinement</td><td>Production Ramp-Up</td></tr>
<tr><td>Ullman (2002)</td><td>X</td><td>Project definition and planning</td><td>Specification definition</td><td colspan="2">Conceptual design</td><td colspan="2">Product development</td><td colspan="2">Product support</td></tr>
<tr><td>Cross (1996)</td><td>X</td><td>Problem</td><td>Sub-Problems</td><td colspan="2">Sub-Solutions</td><td colspan="2">Solution</td><td colspan="2">X</td></tr>
<tr><td>ISO 13407 (1999)</td><td>Identify need for human-centered design</td><td>Understand and specify the context of use</td><td>Specify the user and organizational requirements</td><td>Produce design solutions</td><td>Evaluate designs against requirements</td><td colspan="2">X</td><td colspan="2">X</td></tr>
</table>

Following those four main phases comes the ‘implementation’ phase, which is included by four authors (Ulrich and Eppinger, 2007; Pugh, 1991; Ullman, 2002; Baxter, 1995), describing what happens when the final product design is completed. Another aspect of these processes is that their linearity; they offer a step-by-step process to accomplish the final objective.

If this framework permits one to analyse and compare the general structure of the PDD processes, he does not tell ‘all the story’, namely, ‘what’ and, must important, ‘how’ the overall processes are done in each of the several phases. In order to make a more clear understanding of the phases of each process, the methods, techniques, and ‘tools’ that characterize each of them were dissect in detail.

It is very difficult to establish relations between PDD processes, while in one hand processes have been developed by different authors and process-targets, in the other hand they all tend to illustrate a process that, although having particular aspects, could be implemented for several targets. From the analysis of the several methods and tools that each of the processes contained in their different phases, it is possible to say that:

- The ‘necessity’ and the ‘analysis of the task’ phases are for collecting information and define the task. Several methods are implemented in order to achieve this, raising from ‘product segment maps’, ‘function analysis’ or ‘product-market-matrix’. One method that is common to all is the ‘Quality function deployment’ and all the phases end with a ‘product plan’ or a ‘product design specification’. The differences are in the focus of the process itself, and some are clearly related to the product (Pahl and Beitz, 1999, Cross, 1996, Ullman, 2002) in performance and value, others reflect the focus on the product and the market (Pugh, 1991, Baxter, 1995), while one concentrates all the focus stated plus the management of the process itself (Ulrich and Eppinger, 2007);
- The ‘conceptual design’ phase, despite the different methods which are implemented, can be separated in two subsequent steps - analysis and synthesis. In the first step several methods are used, such as ‘problem decomposition’, ‘conjoint analysis’ or ‘customer selection matrix’, they all are performed in order to obtain a greater understanding of the product in hand. Afterwards, several creative techniques such as ‘brainstorming’, ‘gallery method’ or ‘morphological charts’ with the purpose of having some concepts for the product are listed. The second stage reflects one common activity – the evaluation of the developed concepts. This evaluation takes place at

the end of the phase, and is made by several distinct named methods – ‘evaluation criteria’, ‘concept evaluation’, and ‘concept screening/scoring matrix’. It can be said that, in general, they are all the same, having little differences, mainly present in the precision of the methods and the number of subsequent steps,

- The ‘embodiment design’ and ‘detail design’ are the phases in which there are more differences among the several authors. If from a first analysis one can say that the employed general methods can be framed into the DFX strategies, a more detailed analysis reveals the specific differences. For Ullman (2002) the phases are the same and are considered a ‘product development’ phase with the methods relying in ‘concurrent design’, several analysis and DFX strategies. For Pahl and Beitz (1999), although presenting distinct phases, present DFX strategies for the first phase and just a merely finalization of the product with a document paper in the next phase. Cross (1996) discusses the importance of ‘value engineering’, and Baxter (1995) relies on the ‘product feature permutation’ and ‘design integration’. Pugh (1991) as illustrated before, groups the ‘conceptual design’ and the ‘embodiment design’ phase living the ‘detail design’ for ‘functional cost analysis’ and again for the ‘method of controlled convergence’. One important point in Pugh’s PDD is that it is established by a divergent (analysis) convergent (synthesis) activity along the overall process. Ulrich and Eppinger (2007) are the only authors that discuss the issue of ‘product architecture’ in detail and the ‘assembly efficiency’ of the product;
- The last phase – ‘implementation’ is better defined in two (Ulrich and Eppinger, 2007, Pugh, 1991) of the four PDD processes that fulfil that phase. The other two just mention the documentations for the manufacturing process.

3 RESEARCH AIM

When the PDD processes’ analysis described in this paper was started, the aim was identifying the most promising process to be employed in technology based-products. Through this approach one can decrease the gap between design research and design practice, in order to improve design processes. Dissecting the different design processes and studying them in detail can lead to improvements in the effectiveness and efficiency. From the analysis it becomes obvious that processes were conceived for development of new products. Whenever the analysis of existing products is discussed, it is in the framework of analyzing competitors’ products to establish or define product design specifications. In other words, none of the studied processes are well suited for development of products that need to perform their function coupled with other already existing products.

This type of PDD process unquestionably require a profound analysis of the shape, size, and other physical and functional characteristics of the existing products. Only by doing this it becomes possible to develop a product with embedded microelectronics which can be coupled to several different products. Another gap in the analyzed processes is the absence of users along the overall process. Although some of the processes suggest the incorporation of users in the process (Ulrich and Eppinger, 2007, Pugh, 1991), this is merely in the early phases, with the intention of understanding market needs. Therefore, the aim of incorporating microelectronics into an already existing product requires a profound analysis of the product itself and the users’ perception/interaction with the product. The aim of this research is to understand the importance of users in the development process of such a specific product by engaging the user in all the activities/tasks that need to be performed. By investigating the different roles (e.g., direct vs indirect participation; feedback) that users take in the PDD process, the knowledge to understand the needed activities is central, in order to understand adaptations and difficulties for implementing a new microelectronic device in a existent product. This knowledge could be of two different levels – From product features and specifications, to PDD process improvements.

4 RESEARCH METHODOLOGY

The adopted methodology, and that can be seen in figure 1, is only defined for the first three phases of the PDD process – Necessity, Analysis of the task, and Concept Design (From Table 1). So, the end of this PDD process’s part is the definition of a concept design. In this figure there are four different stages, in order to provide a clearer understanding of the implemented methodology. Then, each stage is a precise task. As stated, PDD normally is driven by ‘Technology’, ‘Market’ or ‘Management’ factors. These are the different needs of developing a new product, so it is possible to say that in the beginning of the design of each product there is always a problem to face. It has been widely recognized that problems are ill-defined (Rittel and Webber, 1984), because they are not completely determined. This is why there is a necessity to fully develop a project statement. To develop the project statement there are three methods that need to be implemented. These methods present two out-puts - list of needs and need statement - that constitute the problem statement.

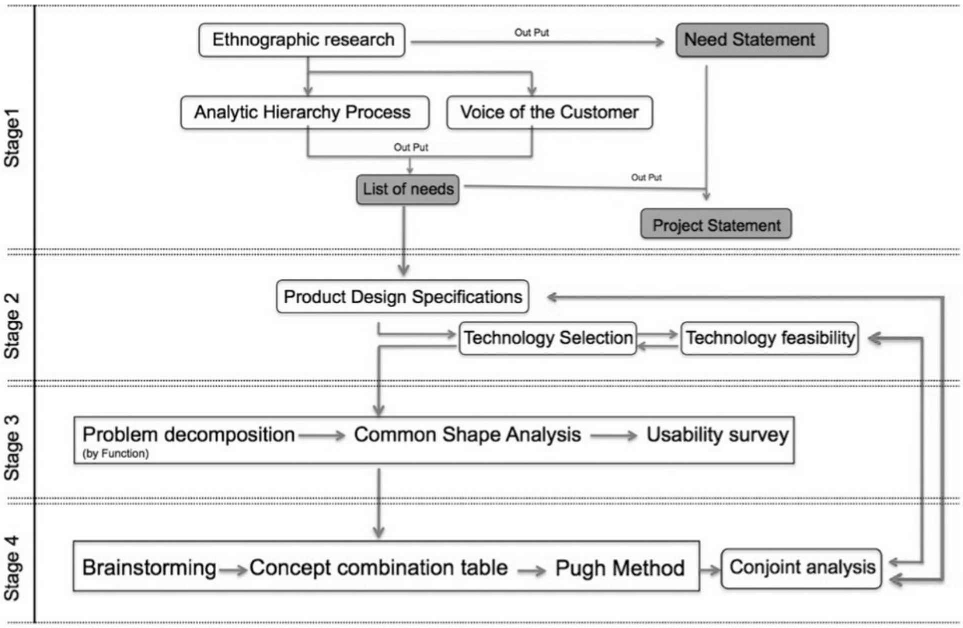

Figure 1. Flow diagram of the PDD process implemented

In this initial stage the methods are: Ethnographic Research, Analytic Hierarchy Process, and Voice of the Customer. Ethnography, in general terms, is the description of a social group based in the observation of their behaviour in their own environment. As stated in PDD processes, problems and their discovery is a difficult task, and an imperative objective for success. In order to obtain that, an ethnographic research is a powerful method, since it permits to define and understand the users, how they interact, what they want, their perceptions and behaviours. Through this method it is possible to find needs that were hidden and know the impact of a product in a specific context of use. This method, combined with the Analytic Hierarchy Process, enabled the understanding of the weight that every user had in the PDD process. Several users can use the same product for distinct purposes, and in different ways. The last method – Voice of the Customer- is a common technique, used to identify what the users really want from the product. The second Stage in this PDD is to develop the Product Design Specifications (PDS) and to select and evaluate the technology that is going to be implemented in the product. As stated by Pugh (1991) the constituent elements of a PDS are applicable to all products, independently of the technology used. That is why selection and validation of the technology are listed after. Stage 3 has its focus on the evaluation of the existing products and the way that users perceive them. This combination of methods brings knowledge on the shapes and forms that are going to be the basis for coupling the add-on product, but at the same time the understanding of existing protocols of usability that users do not consider changing. The last stage is where creative techniques and the evaluation of concepts are done. The combinations of methods in all Stages are dependent on the user participation. Therefore it is possible to say that all the methods used in this process have direct or indirect participation of the end user.

5 RESEARCH CASE STUDY

5.1 Stage 1

When producing medical devices, manufacturers must design them in order for them to fit the intended purpose, not only in design, manufacture and finish, but also by selecting adequate materials.

For surgical instruments, usually only stainless steel (hardened, non-rusting) can meet the tough requirements in terms of tenacity, rigidity, blade characteristics, wear resistance, and corrosion resistance. Surgical instruments are a major asset and represent a significant share of the total capital spending of a hospital. Typically, they have high unit cost compared with many other industries. It is therefore important to be able to track the product as it moves along the supply chain. It is even more important to track the product inside the health provider's facilities, during use, cleaning and sterilizing. As such, we have selected the issue of coupling a microelectronic device to surgical instruments in order to track them as a case-study.
Despite first appearances, this is not a trivial task, as there are many challenges in the incorporation of a microelectronic device in surgical instruments, including: the environmental conditions, as the device needs to perform in high humidity, contact with metal surfaces, need to withstand extreme temperatures, and other factors. Also, it must be insured that the placement of the microelectronic device poses absolutely no threat to the patient, nor hampers or limits the performance of the health professional using the surgical instrument. Although the major improvement in coupling a microelectronic device will be seen in the performance of the scrubbing nurse and on the sterilization technician, surgeons' procedures and requirements are the most critical issue. Therefore, one of the goals is the development of a product that features an embedded microelectronic device, and can be physically coupled to surgical instruments, with no impact on its usability. The major task is to develop this product in a way that allows it to be coupled to a large number of existing surgical instruments; at the very least, all instruments contained in a generic set such as that shown in Figure 2.

Figure 2. Surgical instruments generic set.

A surgical generic set is composed by two needle holders, twelve haemostatic forceps, three scissors, two dressing forceps, two tissue forceps, two scalpel handles, a Backhaus towel forceps and a McGivney forceps, in a total of twenty five instruments.
The inclusion of the tracking device will allow for a fast and accurate count during surgical and sterilizing operations, and, at the same time, the knowledge of the number of uses that a specific instrument has had, as well as the specific set to which it belongs (since several sets can be used in just one surgery and typically end up mixed together). This 'system' will prevent several typical errors, such as miscounting, misplacement, theft, and accidental disposal of instruments, as well as allowing for full traceability of the instruments. This product will allow automated, none-line-of-sight inventory, meeting the requirements of the surgical environments and the needs for product traceability.

5.2 Stage 2

One of the technologies being considered by many industries to face the problems of traceability is Radio Frequency Identification (RFID). This technology involves electronic antennas that emit radio signals and devices (readers) that process the signal that is returned by the RFID tags. This method of auto-identification can be used to communicate seamlessly with components, products and assets in the supply chain. It has the potential to revolutionize the global supply chain, logistics and inventory management. Unlike the bar-code, this technology will eventually network physical objects without human intervention, and operate seamlessly throughout the environment. Thus, it features high potential use for tracking surgical instruments. As stated in Stage 1, several high level specifications need to be evaluated. In this case, technical feasibility of the selected technology was assessed.

Therefore, the smallest RFID (glass ampoule tag) available in the market was selected, with approximately 12mm length x 2mm diameter with 64 bits capacity, and attempted to make a mould injection of the device into a polymeric test specimen (Figure 3) to see if the RFID was damaged by the high temperature and pressure, and to validate that the position of the RFID did not change with the flow of the polymeric material during the injection process.

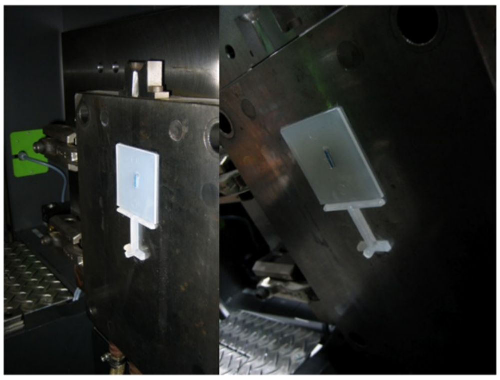

Figure 3. Injection moulding of an RFID tag in a test specimen.

5.3 Stage 3

This stage is of paramount importance, since placing a novel feature in surgical instruments (such as an externally coupled product) needs to be very carefully considered. Surgical proceedings cannot be modified easily, nor can these modifications to the surgical instruments hamper the way surgeons handle them. Thus, for the shape analysis previously discussed, a 3D scanner was employed to obtain models for each component in a generic set of surgical instruments. The 3D models of the surgical instruments were studied with a software (Geomagic qualify) in order to identify common zones in the different instruments (Sampaio, Simões and Pontes, 2013) (see Figure 4).

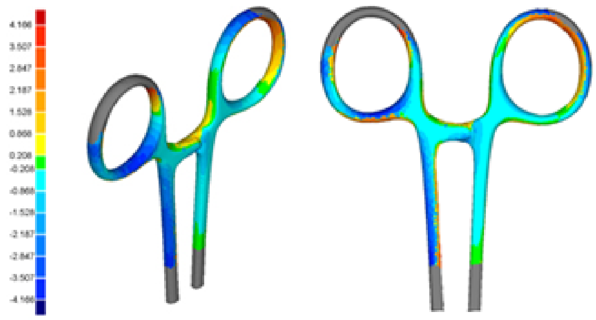

Figure 4. Common shape analysis of the needle holders with the hemostatic forceps.

Simultaneously, inquiries were made with practitioners (medical doctors) in order to establish which areas of the instruments were candidates for coupling an external component in, without having a negative impact on the surgical procedures. Doctors were requested to mark in pictures of the instruments which areas must not be affected in any way, either due to becoming in direct contact with the patient or being used by surgeons to handle the surgical instruments (an issue made even more complex by the fact that different practitioners hold and use the same instrument in a different way). A typical example of this study is shown in Figure 5.

Figure 5. Identification of zones with different functions in a *surgical* scissors.

Using this approach, with the combination of shape analysis through 3D software and the survey conducted on several independent medical doctors (surgeons), it was possible to establish likely zones for coupling the RFID-enabled external product to the instruments (Figure 6).

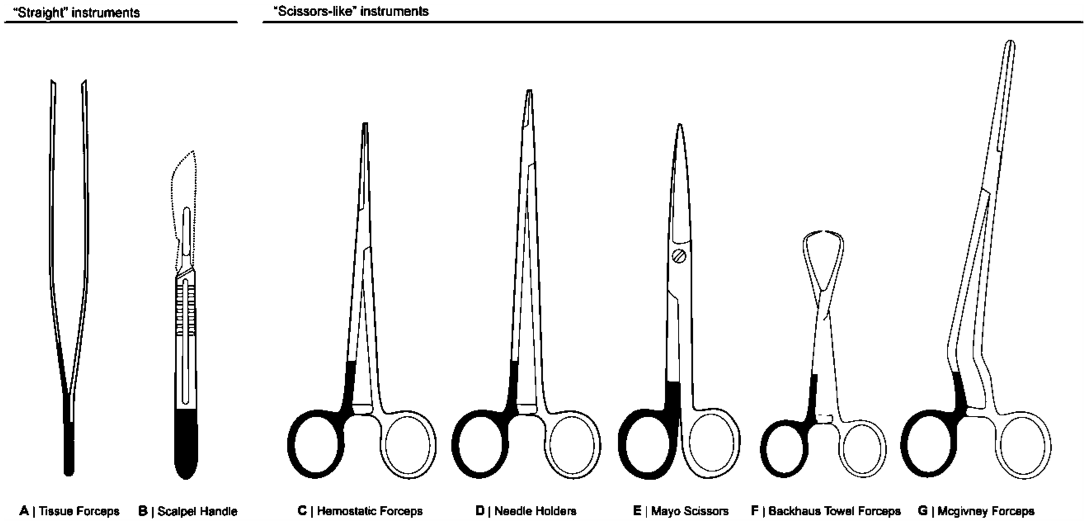

Figure 6. Result of the possible zones for coupling the RFID (in black).

5.4 Stage 4

A major aspect in obtaining successful product development is the involvement of users throughout the PDD process. This is clearly the case of surgical instruments. Operating rooms are places where unforeseen circumstances need to be controlled so that mistakes are minimized (ideally, prevented). Thus, after identifying the possible zones to couple the external RFID-enabled device, it was necessary to develop the first concepts. Following the previously described stages, the next logical step was to conduct a brainstorm session, which included the participation of surgery specialists. In the brainstorming session, surgeons, sterilization technicians, and designers have produced several concepts and discussed them in order to match the requirements listed in stage 1, and the selection of the technology in Stage 2. From the several concepts that resulted from brainstorming, two were selected for development.

6 DISCUSSION – NEW MODEL

The analysis of the research case study demonstrates the importance of integrating the user in the design process, from the first phase, and particularly in the case of the users' active participation. The UCD process model does not make a distinction between users, treating them as equals' through the design process. In a complex product design process, knowing all users and their relation to the product makes it possible to determine the needs for each type of user. Additionally, the activity that is performed in order to overcome a need-specification could integrate the specific user in order to not bias the development of the final solution with the participation of an inappropriate user.

Developing specific activities with the right user seems paramount, in the light of the developed research. The allocation of users by the performed activity corresponds to an active participation in shaping the product and the quality of the final solution.

Summarily, the difference from what has been learned and the UCD model relies on 3 points: First, users that interact with the product are different, and the way to understand those differences is from investigating the real context of use. Second, since users are different and interact with the product in different ways, their needs are also different. It is necessary to investigate on those needs by distinct users. Third, in the development process different activities are performed in order to overcome different problems. These problems are associated to a specific product design specification that was developed through the needs of a particular user. Allocating that user in the activity is paramount.
As a result, a modified model is presented for a more accurate integration of users in the development process. The three phases of the new model are presented in Figure 8.

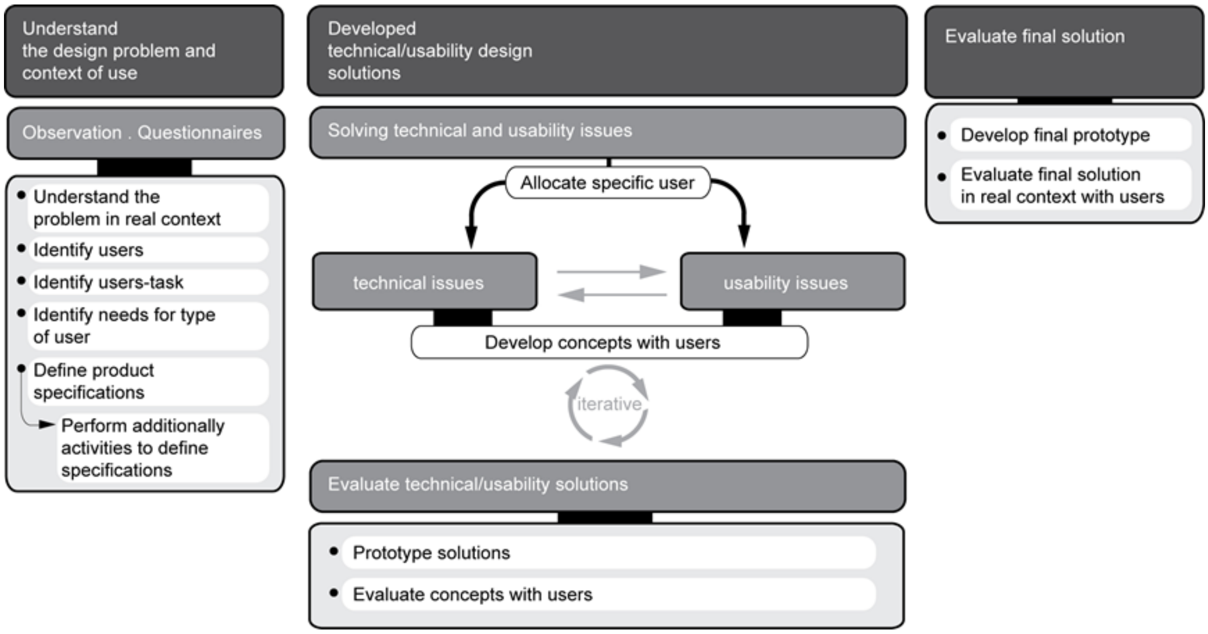

Figure 8. Descriptive model for specific *users' integration*

The first phase is almost the same as what the UCD model proposes (Understand and specify the context of use). The main difference is the investigation, and subsequent analysis of the users involved. In this phase it is necessary to understand the environment, the tasks and the users (as in the UCD model), but the most important is to establish relationships between the tasks that are performed and what type of user performed those tasks in what specific environment. In other words, it is necessary to determine who the primary and secondary users are. The final goal of this phase is to understand the design problem in order to develop the product design specifications, from the needs of the specific users. When the observations and questionnaires obtained on this phase are not sufficient to establish all the metrics needed for the product design specifications, further analysis should to be performed. For instance, in the design project developed in this research, performing observation in the real context of use in order to achieve specific measures of time on task were necessary. In the end of this phase it is necessary to develop a project statement document that concerns all the investigation that was performed, and also all the analysis that were made.
In the second phase, the purpose is to produce a conceptual design solution from the development of the technical and usability problems that were investigated and formalized in the former phase. Understanding the different problems makes it possible to establish the activities that are needed in order to overcome those issues. Then, allocating the specific user to the activities of solving these problems is an imperative, since it improves the desired outcome and makes the knowledge-exchange possible between them. As users have different needs, developing the efforts to fulfil those needs with the specific user makes possible to perform a development in parallel and therefore the path to rapidly assess both solutions and establish a concept in a collaborative session with all users. This session is the activity where solutions which were developed in the technical and usability problems meet, in order to serve as input for the development of concept designs. The outcome of this step is to prototype the solutions and then perform evaluations with the users. These two final steps are an iterative process, since the result of the evaluation could produce insights for necessary modifications. The correct allocation of users to the several initial activities in this phase can ensure a more effective

and rapid development of the product, since the user participates and subsequently validates the different solutions. The iterative of the last two phases is needed, given that users express themselves better when they are in contact with a real structure of the product. As such, in the view of this proposed process and in order to maintain the rapid product development, the prototyping of the concept solutions needs to be performed within a small time frame.

In the last phase, the focus is on the evaluation of the final solution. This final solution needs to be performed in the real context, with the specific user. The observations that were performed in the initial phase need to be developed again, this time with the proposed solution (i.e., new product). In order to accomplish this, fully functional prototypes are necessary. The evaluation is centred in confirming that the product design specifications were fulfilled and therefore the needs of the users were satisfied.

7 CONCLUSIONS

The most widely employed PDD processes have suffered little to no changes in recent decades. Thus, they are not optimized for some characteristics of current technology-driven products. It is particularly the case of embedded microelectronics. It is possible to identify minor changes to traditional PDD processes to increase efficiency and improve the odds for the success of the developed product.

In this work, multiple PDD processes were analysed and a design process which was implemented to a specific case-study was presented, namely the incorporation of RFID tags into surgical instruments. From the knowledge gathered on this case-study, a new model for this type of products was defined. This model clarifies the integration of the different users in a descriptive approach. The main scope of the model is to provide the understanding of the different users and their needs and the way to implement active participation in a wise manner.

User integration in design processes has been introduced to design studies with the user-centred design model. With the UCD model, the design processes are structured in the understanding of the users' needs and on the evaluation of design solutions against users' requirements. This new model, however, proposes a more essential and selective understanding of users, based in their relationship with the product. The aim of achieving multi functionality through an embedded microelectronic add-on showed the importance of acknowledging the users and their differences, and the way that this concept improved the desired solution and the design process as well.

In sum, this revised model relies on the fact that users that interact with the product are different, and that they interact with the product in different ways, so their needs are also different. Therefore, since that during the development process different activities are performed, in order to overcome the different problems, these problems are associated to a specific product design specification that was developed through the needs of a particular user. Allocating that user in the activity is paramount.

REFERENCES

Baxter, M. (1995) Product design: a practical guide to systematic methods of new product development. New York: Chapman & Hall.

Belliveau, P., Griffin, A. and Somermeyer, S. (2002) The PDMA toolbook for new product development. New York: Wiley.

Cross, N. (1996) Engineering design methods, (2nd. Ed.). Wiley.

ISO 130497 (1999) Human-centered design process for interactive systems. Tech. rep.

Pahl, G. and Beitz, W. (1999) Engineering Design: A Systematic Approach, (2nd. Ed.). London: Springer

Pugh, S. (1991) Total Design. Integrated methods for successful product engineering, Addison-Wesley Pub. Co.

Rittel, J. and Webber, M. (1984). Planning problems are wicked problems. In: Cross N. (Ed), Developments in Design Methodology, Wiley, pp. 135-144.

Sampaio, A.M., Simoes, R., & Pontes, A. (2013) Shape analysis in the design process of products with embedded microelectronics. In: Bártolo, P., et al. (eds). High Value Manufacturing: Advanced Research in virtual and rapid prototyping. CRC Press, London, pp. 649-654.

Simoes, R. and Sampaio, A. M. (2008) Effect of technology-driven products in the future of product design and development, RPD-2008 Designing the Industry of the future, Oliveira de Azeméis.

Ullman, D. (2002) The mechanical design process, New York: McGraw-Hill.

Ulrich, K. and Eppinger, S. (2007) Product Design and Development. McGraw-Hill.