USER CENTERED DESIGN AND TRIZ INTEGRATION IN AN INNOVATIVE DESIGN ATMOSPHERE

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RESUMEN

Se propone una metodología de diseño que integra la metodología de Diseño Centrado en el Usuario y la Teoría de TRIZ. La metodología se divide en cuatro etapas: Observación, marcos de referencia, imperativos y soluciones. La viabilidad para la integración de las dos metodologías se demuestra en un caso de estudio. Este trabajo tiene como objetivo identificar oportunidades de innovación y de alguna manera reducir el tiempo durante el proceso de diseño. La metodología propuesta se aplica en un caso de estudio, el diseño de una silla de ruedas geriátrica para países en vías de desarrollo. El diseño de esta silla de ruedas engloba todo un proceso de diseño, desde la obtención de las necesidades del cliente hasta la construcción de un prototipo funcional.

ABSTRACT

This paper proposes a methodology that integrates the user centered design (UCD) approach and the TRIZ theory. This methodology is divided in four stages: observation, framework, imperatives and solutions. The integration feasibility of the methodologies mentioned above is showed with a case study. This proposal is aimed at identifying innovation opportunities, and somehow it addresses to save time during the product design.

The proposed methodology is applied in a case study, which is the design of a geriatric wheelchair. The design of the wheelchair includes the activities carried out from user needs gathering to the functional prototyping of a design concept.

INTRODUCTION

Research in engineering design is categorized into design philosophies, models and methodologies. Design theory is a collection of principles that are useful for explaining a design process and provide a foundation for basic understanding required to propose useful methodologies [13]. Rabins states that design theory refers to systematic statements of principles and experientially verified relationships that explain the design process and provide the fundamental understanding necessary to create a useful methodology for design [17]. Design theory explains what design is, whereas design methodology is a collection of procedures, tools and techniques for designers to use. Design methodology by its part is prescriptive as it indicates how to design [18]. A design methodology should foster and guide the abilities of designers, encourage creativity and at the same time drive home the need for objective evaluation of the results [14].

Pahl and Beitz identified four phases that are common to any prescriptive model for design: Task clarification, conceptual design, embodiment design and detail design [14]. Asimow proposed three phases of design: Feasibility study, preliminary design and detailed design phase [15]. Michael French proposes an eight phases design: Need, analysis of problem, statement of problem, conceptual design, selected scheme, embodiment, detailing and working drawings [25]. Dieter and Schmidt proposed an eight stages methodology: Problem defining, information gathering, concept generation, concept evaluation, product architecture, configuration design, parametric design and detail design [15]. Ulrich and Eppinger propose a six phase methodology:
Planning, concept development, system level design, detail design, testing and pilot production [19]. Ullman proposes a six phase methodology: Product discovery, product planning, product definition, conceptual design, product development and product support [20]. Despite all the methodologies compete to some degree of continuous innovation there are new tools and methodologies aiming to incorporate innovation in as a core design strategy rather than traditional design methods.

The authors point of view is that in which the role and vision of designers, engineers, design companies and design laboratories inside universities have changed due the complexity of the new challenges in current economies. Nowadays companies throughout the world are seeking competitive advantage through innovation. Today innovation is about more than new products, it is about reinventing business processes and building entirely new markets that meet untapped customer needs [22]. Furthermore evolution of science and technology has reached tremendous rate. Major breakthroughs in sciences, technology, medicine, and engineering make our everyday life more and more comfortable.

Due these changes, it is necessary for the Engineering design field to propose new methodologies aiming to clarify and understand problems in a different approach. In this research field there are methodologies centered in foster innovation. Tom Kelley and his company IDEO, proposes a five phases methodology to innovate not only in physical product design but services: Understanding, observing, visualizing, evaluating and refining and finally implementing are the phases proposed in this methodology [20]. Kelley also proposes a methodology for Human Centered Design aiming to develop a product, service, environment, organizations and modes of interaction with a deep understanding of the user [21]. Beckman and Barry by their part propose a generic innovation process that can be applied in: hardware & software development, business models and products creation, this proposal takes its basis in the Owen’s model and it moves between the concrete and the abstract worlds and it alternately uses analysis and synthesis [5]. In the other hand there are other former theories such as The theory of inventive problem solving (Abbreviation derived from the Russian title TRIZ) , TRIZ is a problem solving methodology developed in Russia, which proposes structured in the basis of innovation and can be used as a set of innovation tools for a better problem understanding.

In this paper, a design methodology which integrates the user centered design (UCD) approach and the TRIZ theory is proposed. The usefulness of the proposed methodology is centered on the opportunities of integration and enrichment that exist between the UCD approach and TRIZ along their stages as well as in the complementarility of their innovation tools. The proposed methodology combines concrete and abstract levels along its stages for a better decision making exercise. In particular, in the framework and imperatives stages of the methodology proposed, the integration feasibility between UCD and TRIZ is emphasized due to the abstraction levels reached by the two methodologies.

The proposed methodology is applied on a case study, which is the design of a geriatric wheelchair for developing countries. The design of the wheelchair includes the activities carried out from user needs gathering to the functional prototyping of a design concept. The stages of the methodology are described in the case study and it is pointed out the tools used and their features. The wheelchair developed satisfied the customer requirements, the feedback received from engineering and medical experts has been positive, the final concept integrates innovative features which could be patented. This shows that the methodology really can help to obtain useful results.

In the first part of the paper background on UCD approach and TRIZ is presented. After, the proposed methodology is detailed and its stages are explained. Then, a case study shows the use of the methodology and at the end of the paper a discussion, conclusions and future work are presented.

The authors have developed the presented methodology based on several case studies that have applied the User Centered Design approach and TRIZ.
BACKGROUND

User Centered design approach

In the past society moved as a mass, for example, the persons wore the same kind of clothes, and they listened the same kind music. But this is not longer happening. Today marketing organizations, design firms and companies must do more than appeal to an undifferentiated mass market. They must learn to deliver to individual customers.

The user centered design approach is a trend in product innovation which emphasizes the user participation in the product development process by a deeply need understanding. Designing meaningful and innovative solutions begins with needs, hopes and aspirations understanding, designers understand that needs are important. However, an understanding of people’s needs can be leveraged across an entire business activity, providing value beyond the development of any single product.

A key issue for the user centered design approach is that looking for needs rather than specific solutions keeps all possible solutions open for consideration.

TRIZ

TRIZ was born as a theory; however a discussion is done on what really is: a methodology, a technique or a set of techniques. In any case, TRIZ is focused to solve engineering problems in an innovative way. For the purpose of this paper, TRIZ is seen as a set of innovative-problem-solving-tools. TRIZ was developed by Altshuller from studying thousands of patents and identifying the key design principles as well as a number of design patterns. As a set of techniques, TRIZ also can be used to help the designers to understand the requirements, to identify the problems and the causes, and to define how a system should work. TRIZ guides designers through design principles to innovative solutions breaking paradigms and exploring new ways to solve problems.

The TRIZ way to solve problems is through its translation into abstract situations. Therefore the set of tools that composes TRIZ helps to define the problem, and even more to understand it in a better way Throughout the TRIZ methodology several tools can be used to define the product.

An opportunity for the integration of the User Centered Design Approach and TRIZ

TRIZ presents a complete design methodology based on a theory of innovation, a process for describing a design problem, and several strategies for solving a design problem. The UCD approach, by its part, focuses on user’s needs deeply understanding. This paper proposes to integrate the UCD approach and TRIZ in order to perform a deeply understanding of the user’s needs and the problem. Some opportunities of integration and enrichment, and comparisons of the two methodologies have been presented previously by Hay and Van Pelt. Also TRIZ has been integrated and matched with other methods and methodologies such as Six Sigma, DFMA and QFD. In other cases TRIZ specific tools has been applied to particular tasks. Dieter and Schmidt refer to TRIZ in the concept generation stage. What distinguishes this paper from the mentioned work is the deep level of integration between UCD and TRIZ enable by the methodology proposed, which is reflected by the number of TRIZ techniques involved and proved by the case study.

THE UCD-TRIZ INTEGRATION

The UCD-TRIZ integration is based on the UCD approach and the set of innovative problem solving tools of TRIZ and the generic innovation process proposed by Barry and Beckman and the Owens model. By analysing abstract and concrete levels of perception a graphic model of opportunities of integration is proposed (Fig 1) based on experience gather from the application of UCD and TRIZ in several case studies. The UCD-TRIZ integration is divided into 4 stages in order to clarify the objectives and goals achieved in each stage. The stages are:

1. Observation: Deeply understanding of stakeholders (customers, users, value chain partners, etc.) needs. This stage is an opportunity to understand how the product or service is being used, and how its benefits are derived in the context of use. Through observational or ethnographic research that seeks to understand not only the fundamental use
and usability needs but also the meaning based needs [8].

2. **Framework:** To ensure that the real problem is being solved. In this stage the goals relies on the identification of particular patterns and nuggets as well as innovation opportunities. The ultimate goal is to reframe, to target the users problem in a different way. The tools used during this stage are as follows:

- **Personas:** Virtual customer profiles called personas which keep characteristics of real customers.

- **The resources window:** TRIZ tool (TT) which helps to visualize free unmet resources.

- **The constraints window:** TT used to visualize the space-time constraints that must be considered during the design process.

- **Mind maps:** Flexible tool to organize the information gathered through research in order to analyse it.

- **Triangle redefinition:** This TT helps to maximize or minimize the problem, pointing out or generalizing the value points or the understanding of the problem.

- **Function diagram:** TT which helps to visualize how and where the system’s elements get involved pointing out the way of interaction and their contradictions.

3. **Imperatives:** The value prepositions that must be met by the new concept is proposed [7]. The value propositions describe the tangible benefits customers will derive from the ultimate product solution.

- **Contradictions matrix:** TT which guides designers to the most useful inventive principles. Recall that a technical contradiction occurs when an improvement in a desired engineering parameter of the system results in deterioration of the other parameter. This TT can be used either in the imperatives stage or in the concept generation stage.

4. **Solutions:** Based on the imperatives, the final aim of this stage is to generate, select and evaluate the final concepts in order to collect real feedback from final users. This stage includes (a) concept generation, (b) concept selection and (c) concept evaluation.

*Figure 1. Qualitative representation of the integration opportunities of User Centered Design approach and TRIZ*
CASE STUDY: THE GERIATRIC WHEELCHAIR

In order to further explain the proposed method and show its application and utility, the design of a geriatric wheelchair is presented as a case study.

Observation

To identify stakeholders' needs interviews were applied and several visits and observations were carried out. Some of the stakeholders interviewed were: Geriatricians, nurses, caregivers for elderly, adult persons between 60 and 70 years old.

Based on the information gathered, a user needs segmentation was defined (Fig. 2).

Figure 2. User needs segmentation

Framework

As described above, this stage of the proposed method takes advantage of several abstract techniques. In the case study, the application of each one of them is described.

- **Personas:** Based on the user needs segmentation, particular patterns and user characteristics were selected. They were used to define 5 personas. 2 of them are described below:

1. **Teresa Gutiérrez**

   She is 82 and lives with her daughter. She suffers from osteoporosis and problems in the thighbone. Pensioner, her hobby is cooking and watching television. Teresa normally goes with her family to the supermarket and to her hospital check up.

   Even though she has problems in the thighbone, she does not want to use a wheelchair.

2. **Carlota Ramirez**

   She is 87 years old and lives in a nursing home. She has no resources and suffers from cataracts and osteoporosis. She has no family and receives a grant given by the federal government. She has other money source: the sale of embroidery. She likes going to church and she makes long walks while going to hospital.

   - **The resources window:** Resources play a big part throughout the innovation process. This is an excellent framework tool for focusing our thinking [u]. During this exercise it is reviewed, the past, the present and the future of the system and its environment. In the case study, the following unmet resources were found:

     1. User features. The main user’s features were analyzed, and what was found is that user’s will have a *small size and less weight after sixties*.

     2. Low maintenance. When designing, **low maintenance** components must be considered.

     3. Cities modernization. Along this parameter a *major infrastructure* (ramps, elevators and access) can be considered in future scenarios as well as a major conscious for aging cares.

     4. The lack of an sports culture and a poor feeding are generating a **wide potential market size**

     5. Increasing in life expectancy. Through this aspect the potential market size *gets increased* as well as the *use stage* in the product life cycle.

   - **The constraints window:** Constraints are strategies for identifying the bottlenecks. Other way in which constraints can be seen is as obstacles when designing. The following are the main constraints found in developing countries for the case study:
1. Pavement roughness and lack or ramps: This is a main feature of a developing country.
2. Inadequate public transportation.
3. Low salaries which means a need for a low cost device.
4. Psychological rejection for a wheelchair.
5. Corrosion and material wear.

- Mind map: The amount of information carried in this stage, leads to organize and visualize innovation opportunities by the use of a flexible innovative tool called mind map (Fig 3).

- Redefinition triangle: This TT is a framing tool which is used to understand the problem nature. It is based on the setting of two problem’s views: the narrowed view and the expanded view [9]. By applying this tool the following views were set:
  1. Expanded view: The lack of cares for elderly and the society exclusion of this part of the population generate the need of creating specific products for them.
  2. Narrowed view: Ergonomics aspects are the main focus on this kind of devices.

- Function diagram: The product is linked with its surrender atmosphere using this TT (Fig 4). In the case study, the linked elements are: User, carrier, pavement, stair, ramp and trunk. According to the results showed by figure 4, the following contradictions were found:
  1. Geriatric mobility device-stair
  2. Geriatric mobility device-user
  3. Geriatric mobility device-pavement
  4. Geriatric mobility device-trunk

Analyzing the user needs and getting the research insights in the former stages lead to the following imperatives:
  1. Stability
  2. Safety
  3. Low cost
  4. Comfort
  5. Lightness
  6. Ease of use
  7. Pliability
  8. Ease of clean

In this stage one technique is suggested by the proposed method.

- Contradiction matrix: This TT helps to translate the imperatives found into design principles. The first step is to match these imperatives with the 39 parameters proposed by Altshuller. These parameters are analyzed in the contradiction matrix (Fig 5). The main purpose is to match them to find an
equilibrium which means: “keep a feature and do not get worse other”.

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*Figure 5. Contradictions matrix*

**Solutions**

As mentioned above, this stages includes three steps of conceptual design, generate, select and evaluate. The work carried out for the case study within each of them is presented bellow along with the techniques used.

a) Concept Generation

- Benchmarking

![Figure 6. Benchmarking](image)

Here are presented mobility systems sold in the market were looked for along. The information obtained was summarized and presented in a two diagram according to its cost and complexity (Fig, 6).

By setting the product in a developing country it is defined that customers have a low purchasing capabilities which makes unlikely the acquisition of motorized mobility systems. Because of this, it was decided to design a mechanical wheelchair. By analyzing the mechanical wheelchairs set in the market it was found that there was not a specific wheelchair for the elderly population and the ones that existed did not fulfill the user’s needs. This led to find out a new market opportunity.

- Design principles gathering

The application of the matrix of contradictions (Figure 5) resulted in a series of principles that were applied to get solution ideas. For example, the matrix was applied to solve the contradiction *geriatric mobility device-stair* (Fig. 7). This TT should be asset as required.
To balance the weight of the object and ground adaptability, the contradiction matrix gives four possible solution principles. One of them was elected in the case study, the consolidation. The principle of consolidation suggests that an element can perform several functions simultaneously. In this case study an element implements two functions, moving forward and going up and down stairs.

- System design

For the design of the case study a systems’ separation was carried out. So the wheelchair is composed by the following systems (Fig. 8): Structural system, seat system, absorption system, displacement system and safety system.

b) Concept selection

The final concept sketches were evaluated according to the resistance, the cost and ease of operation (Fig 9).

The final concept is shown in figure 10.

c) Concept evaluation

For the evaluation of the case study concept, a prototype was built (Fig. 11). Three tests were carried out in order to verify the operation of the different product’s systems. The tests were:

1. Up a stair
2. Down a stair
3. Turn

Two of the tests were successful as the product performed as expected. The other identified new problems to be solved and improvement opportunities.

The product was presented to potential customers and all of them gave positive comments.
CONCLUSIONS AND FINAL COMMENTS

This paper presents a new method that integrates the user center design approach and TRIZ techniques. The method is composed by 4 stages, which are described along with techniques that assist to achieve their goals. This allows finding innovative solutions which satisfy user expectations.

The use an utility of the method was illustrated using a case study. The product resulted from the application of the method produced an innovative product (Patent registration MX/E/2010/034127) which has received positive comments from customers even when some problems are still to solve.

The method is a distinctive one as other examples of integration focuses on particular tools or cases. In order to fully validate the proposed method, it is necessary to carry out more case studies.

ACKNOWLEDGMENTS

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