Prototype-Centered Design: For Better Interactive Design Process

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ABSTRACT

Several authors have talked about the complexity of the design activity, pointing several factors to its elevation, such as: globalization, reduction of the development cycle and product diversification, sustainability, rapid changes in user behavior, new materials and production technologies, ... it has expanded the research in methodology and stimulated the emergence of new technologies applied to the development of projects such as: 3D scanning, rapid prototyping and rapid manufacturing technologies. In this context, after several research about methodology and design management, we find that the design process could become more interactive and efficient if the prototyping activity could assume the central role in the design process and if appropriate prototypes were used in each phase, stage and purpose of design. Those factors could improve the management, the communication inside the team and among other actors in the process and expand the insertion and evaluation of user requirements. Accordingly, this article will present the results of a doctoral research in design which proposes a new design methodology centered on the prototype and the results obtained after the completion of a projective challenge to experiment and validate that methodology.

Keywords: Exemplary Paper, Human Systems Integration, Systems Engineering, Systems Modeling Language

INTRODUCTION

We have defined the term prototype as a final project or product that is being developed in full scale and real materials. However, according to Preece et al. (2006, p.240), "a prototype can also be a paper-based outline of a screen or set of screens, an electronic picture, a video simulation of a task, a three-dimensional paper and cardboard mockup of a whole Workstation, or a simple stack of hyperlinked screenshots". Thus, we can define the prototype in the broadest sense as: "the physical or digital artifact developed to understand, explore, evaluate and communicate one or more attributes of the product that is being developed" (Alcoforado, 2007, p.39). In this sense , the prototypes could be made horizontally, vertically or in the scenario form (Greenberger, 1998) , with low, medium or high fidelity (Snyder, 2003; Ullman, 2003; Hold and Hill, 2004; Preece et al, 2006; Righetti , 2005) , and the various representation forms of the prototypes in the design process would allow users to understand and answer questions in a more concrete way, materializing concepts and making tangible the design features. Hartman (2006, p.1) states

“These prototypes are the pivotal media that structure innovation, collaboration, and creativity in design”. The author emphasizes that “Design studios pride themselves on their prototype-driven culture; it is through the creation of prototypes that designers learn about the problem they are trying to solve”. Thus, product design success result from a number of “conversations with materials”, making the activity of "thinking through making", based on interactions, becomes the central concept of the design process.

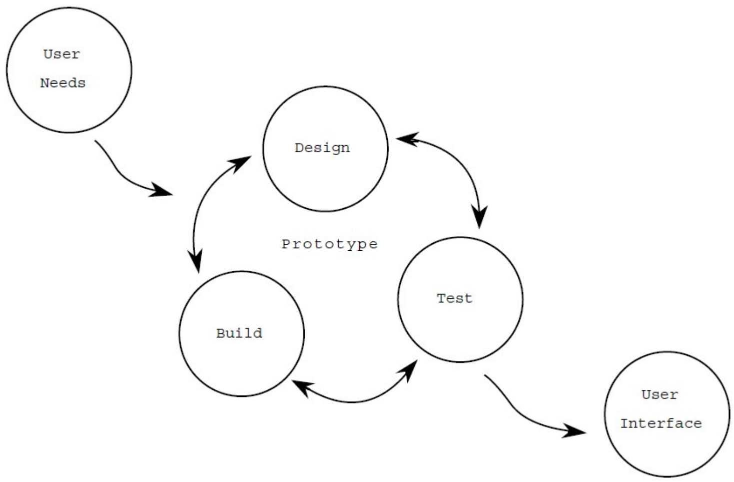
However, in design methodologies, we observed that the prototypes are conceived only in the final stages of the project and that their use is associated with an increase in cost and development time. These aspects can lead readers to reduce the conception of prototypes and restrict their use to the final stages of the project. In contrast, we believe that iterative cycles, conceived with appropriate prototyping, can make development process more efficient and less costly, since detecting and correcting errors in early stages of the design process during is significantly cheaper in comparison to only detecting them during production. In this sense, today's organizations are betting on the increase in quantity of iterative cycles of prototyping as a way of enhancing the quality of products. Thus, in face of new prototyping technologies allowing a broad application in the product design, this paper had as a goal to present a methodology that sets the prototype as the central point in the design process, seeking to make the conception and development more interactive and proposing a permanent dialogue of our ideas to the real world. It can be done through iterative versions of the project, made tangible through prototypes. For this, we present the application developed in order to manage the design process and indicate the most suitable prototype and methods for each stage of the project. We believe that this methodology can contribute in making the process more fluid and structured, leading to a more efficient design process and consequently the products generated from it.

METHODOLOGY, DESIGN AND COMPLEXITY

By analyzing the history of design, it was found that the emerging of design methodology, formalized as it is today, is directly related to the increase of design complexity, to the context of the epoch and to the knowledge scientization adopted by the Hfg-Ulm Design school, in Germany (from 1952 to 1968). At that time the design as a project practice had become a very complex activity. Thus, it was needed a theory that correspond to that complexity. And that complexity was formed not only by the constitution of the object, by its interdisciplinary and transdisciplinary nature, but mainly by the complex multiplicity of the user. For Christopher Alexander (1964), which was considered one of the creators of the design methodology, the need for systematization and planning of the design process is due to several factors which include: (a) Complexity - The project problems became too complex to be handled intuitively, (b) Amount of information - management of information involved in solving a problem. Difficulty of collecting and manipulate, (c) Number of problems - significant increase in the amount of problems involved and (d) Sorts of projective problems – The wide range of problems causes the design to have difficulty in previous experiments. In the period from 1958 to 1966 emerged the first formalized methodologies and several methods for applying the remarkable development of the scientific knowledge of the time in the design process, among which it is possible to mention: Horst Rittel (1958), Christopher Jones (1984), Archer (1984), Gui Bonsiepe (1963) and Tomás Maldonado (1966). Nowadays, we live in a globalized world where competitiveness stimulates more and more the companies to develop innovative practices as a form of adaptation, growth or survival in the market. A dynamic scenario, marked by the acceleration of consumption and reduction of production cycles, companies need innovative work practices and investments in research and development, as a strategy to accompany the market and its competitors. A new complexity that is justifying, once again, the conduct of research and the emergence of new methodologies and project development technologies. To DeGraff and Lawrence (2002), there are external forces, such as technological dynamics and market conditions, which determine the value of the products, those pressures need to be perceived and anticipated by the companies. Ullman (2010, p.2) complements saying that the global market promotes the need to develop new products at a very fast pace. To compete in this market, a company must be very efficient in the design of its products. According to the author, it is estimated that 85% of problems with the new products are related to time-to-market or high cost, and many of those problems are the result of a poor design process. Cross (2005), by analyzing the various models of design methodology presented by several authors, states that there is a need to improve the traditional forms of design and a desire to develop new procedures. One of the reasons was the increasing complexity in modern products with a wide variety of demands and new products that never existed before. Thus, "a new and more systematic approach is needed" (Cross, 2005, p.45). The analysis of those presented aspects about reducing the development cycle of the product extends the importance of research in the areas of methodology, managed product development, methods, techniques and tools that can contribute to a more efficient design process in order to meet those current demands of market and industry.

THE IMPORTANCE OF PROTOTYPES IN THE PROCESS OF DESIGN

Studies show the importance of representations as a strategy to expand our mental abilities and cognitive skills (Ullman et al 1990; Norman, 1988; Rogers, Sharp and Preece, 2006). Thus, the preparation of drawings, sketches, diagrams, maps, notes, models, etc. has a higher function than purely represent our ideas, it allows "to externalize" data which could hardly be analyzed only by mental processes, i.e., in the case of the design, it contributes to broaden our cognitive and projective ability. The Cognitive Model of Newell and Simon (1972) presents the environment of the design information processing system (IPS). In the model there is a space of internal processing (internal environment), inside the brain of the designer and the space of external processing (external environment), out of the designer's brain. In the internal space, it was found two kinds of memory: short-term memory (STM), responsible for the information used to design operations, according to studies, it is fast, but limited to seven cognitive units or simultaneous pieces of information, and long-term memory (LTM), which conceptually has infinite capacity, but low access speed. This memory region is responsible for processing the operators and controllers of the design process. Those operators are responsible for solving the design problems. In the external space, which we are calling “external memory”, we found several ways of storage the design state, which include graphic representations like: sketches, notes, storyboard, virtual prototypes and physical prototypes. “The external environment - paper and pencil, computers, books - has a number of functions in the design process: it is the source of information, an analytical capability, an enabler of documentation and communication, and most important for designers: it is an extension to the short-term memory" (Ullman 2010, p.55). Thus, we believe that the use of the prototype in the design process gives the design a chance to answer questions concretely, materializing concepts and making the characteristics tangible. With it, the designer can obtain context information and explore ideas through the production of communicative and interactive artifacts. "I believe that if we think first about people and then test, test and test the prototypes of our design, we will have a chance to create innovative solutions that people will value and appreciate" (Moggridge, 2006). Jones and Marsden (2006) point 3 activities that we must explore to work effectively with interactive design within the design process: (1) Understand users: their capabilities and limitations, details of how they live, what they do and use (2) Develop design prototypes: create representations of the design to promote interactions that can demonstrate and discuss the design change (3) Evaluation: each prototype is an improved and refined stage of the previous one that evolves through evaluation techniques that identify strengths and weaknesses of the design and especially give the power and security to the staff to make decisions about the continuity and discontinuity of the design. Thus, we can understand that the essence of the design process can be focused on 3 activities: Project, Build and Evaluate. In those phases the prototype is a fundamental part of the iterative process. And that can and should be done in a controlled and systematic iterative cycles, where someone can measure and compare the results with previous cycles, in order to have enough elements for a process of making reliable decisions throughout the entire process of design.



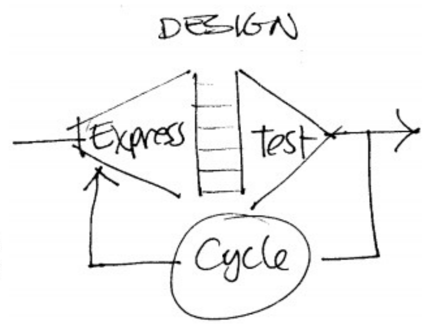


Figure 1 - Design model process by Gayle Curtis and Vertelney (1990, p.07) and Figure 2 - Scheme of iterative cycle of expression of ideas and tests proposed by Bill Verplank (2009, p.04).

We know that we must always test what the product will have to do and how it will do that. That should be done through repeated activities of design-evaluation-redesign, in cycles, involving users, using interactive versions of our ideas, i.e., using prototypes, causing the design to be an activity of interactive exploration where it seeks to establish an ongoing dialogue with the material representation, in order to make the problems and solutions tangible, reducing problems of communication and interpretation.

METHODOLOGY OF DESIGN, CONCEPT AND USE OF PROTOTYPES

When we surveyed in our study various methodologies, including: Morris Assimov (1962), Gui Bonsiepe (1978), Archer (1984), Bernd Loback (2001), Bruno Munari (2002), Nigel Cross (2005), Henrique Rozenfeld (2007), Mike Baxter (2008) and David Ullman (2010), we found that the design process can be summarized in 3 macro-stages: (a) preparation, (b) development and (c) realization. In those stages we found that the prototypes are left to be made in the final stage of the design process and are expected to be applied only after the selection stage of the alternatives. That limits the analysis of usability, functionality and aesthetics of the alternatives and reduces the quality of decision-making process for selecting the best alternative. Thus, the prototype is seen just as a tool for presentation of the project, failing to explore many other possible uses.

Table 01 - Table of prototyping activities in the methodologies (source: the author).

	Design stages														
	Preparation					Development					Realization				
Morris Assimov (1962)									■	■			■		
Gui Bonsiepe (1978)									■	■					
Aicher (1984)										■	■				
Bernd Loback (2001)														■	
Bruno Munari (2002)									■						
Nigel Cross (2005)													■	■	■
Mike Baxter (2008)										■			■		

From the analysis of those methodologies we highlight the following aspects: (a) The activity of prototyping focuses on the final design stages: stages of development and realization. We did not observe the use of prototypes in the process of contextualization, where it is defined the problem and it is collected preliminary data from the users (Table 1). (b) In many of those methodologies the prototyping appears after the process of evaluation and selection of alternatives, i.e., only for the purpose of visualizing the design solution that was chosen. (c) In the methodologies, the prototyping is not taken as a systematic activity, i.e., set periodically by the demands of the product development process. (d) In the methodologies, we also observed that there are no guidelines or tools that help the design in choosing the appropriate prototype that is intended to evaluate in the design. (e) The design methodologies do not reflect in their structures the creation of iterative cycles of generation, construction and test, they also do not have tools for guiding the choice of appropriate prototype for construction, testing and evaluation, which may limit the decision-making process.

Conceptualizing prototypes

Epistemologically, prototype would be the materialization of knowledge. Literally it means "the first of a kind". According to Baxter (1998), in the product design process, the word refers to the two types of representation: (1) in the most precise sense, it refers to the physical representation of the product that will be produced by industry, (2) in a broader sense it refers to any kind of physical representation constructed with the objective of performing physical tests. In the dictionary, the term "prototyping" has been defined as: "the creation of a model, the act of building an original copy", reporting the use of ideal models of example or demonstration conducted by building small parts of something, as a sample to determine the quality of something by testing or simulation performed on an exemplar. Thus, the prototype is not limited to a physical thing, neither to a representation of all characteristics of a product.

Generally many authors around the world refer to the steps of representing characteristics of a product or system through the "prototyping" term, dividing them according to the level of fidelity (low and high fidelity). Thus: sketches, mockups, models and traditional prototypes, are treated as different types of prototypes with different levels of fidelity. Thus, considering the areas of graphic, digital and product design, we have used the following definition to prototypes: “the physical or digital artifact developed to understand, explore, evaluate and communicate one or more attributes of the product that is being developed” (Alcoforado, 2007, p.39).

Classifying Prototypes

According to the German Association of Industrial Designers and Stylists (VDID Verband der Deutschen Industrie Designer) and the German Counsil for Styling, the "models" (for our study, types of prototypes) can be classified as follows: (a) Proportional model (concept model), (b) Ergonomic model, (c) **Model of aesthetics and modeling**, (d) **Functional Model**, (e) **Prototype** (for our study, high-fidelity prototype) and **Pilot** (or production sample). Buchenau and Suri (2005) describes that prototypes are developed for three purposes: (1) establish a grasp of the user experience or context, (2) explore and evaluate design ideas and (3) communicate those ideas to an audience, and in 3 levels: "look like" (visual), "Behaves like" (behavior) and " Work Likes" (operation). From such classifications we realized that prototypes are used to evaluate three levels of interaction with the products: (a) functionality, (b) usability and (c) aesthetic. In order to verify and classify the application of prototypes in realization of aesthetic, functional and usability evaluation of the Design, we consulted several studies in the area and we made some cutouts in the definitions and applications of each type of prototype described by several authors, trying to identify the application of the studied prototypes for each of the channels of communication of: **functionality, usability** and **aesthetics**. Through statistical analysis of proportional mean we made the graph that is shown in Figure 2 where it is possible to classify the prototypes in those channels.

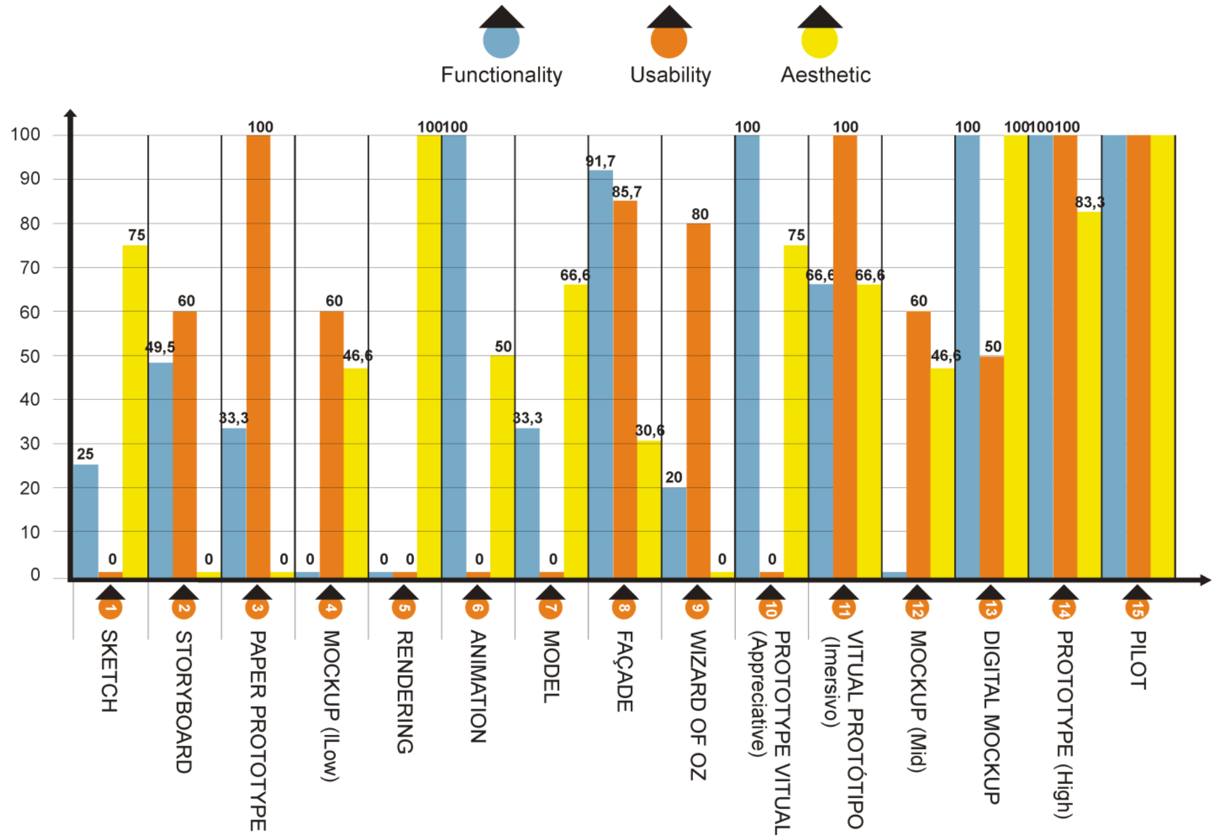


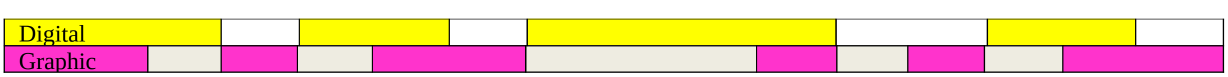
Figure 2 - Framework of occurrences of communication channels for all prototypes (source: the author)

Prototypes can also be classified by the level of fidelity in (a) low, (b) medium and (c) high fidelity (Snyder, 2003; Ullman, 2003; Hold and Hill, 2004; Preece et al, 2006; Righetti, 2005). (a) The low-fidelity prototypes are prototypes with limited functions and interaction, constructed to describe concepts, design alternatives, they allow us to evaluate preliminary concepts or define requirements for the future product; (b) Medium-fidelity prototypes are prototypes used after the initial design stage, for the purpose of detailing the design and validate its usability. These prototypes should already contain some aspects of functionality that enable preliminary tests and (c) The high-fidelity prototypes have a greater commitment to the precision of the representation of the final product that will be implemented, i.e., they are a faithful representation of the product or some features of the products, which could be used for testing and functional evaluation. Therefore, we can classify prototypes by fidelity according to Figure 3.

Sketch	Storyboard	Paper prototype	Physical Mockup (low fidelity)	Rendering	Animation	Model	Façade (not evolutionary)	Digital Mockup (not evolutionary)	Wizard of OZ	Digital Mockup	Appreciative virtual prototype	Physical mockup	Immersive virtual prototype	Prototype (high fidelity)	Pilot
Low Fidelity				Medium Fidelity									High Fidelity		

Figure 3 - Classification of prototypes by fidelity (source: the author)

The prototypes from studies and examples of application can be classified by area of use in digital, graphic and product design according to figure 4.



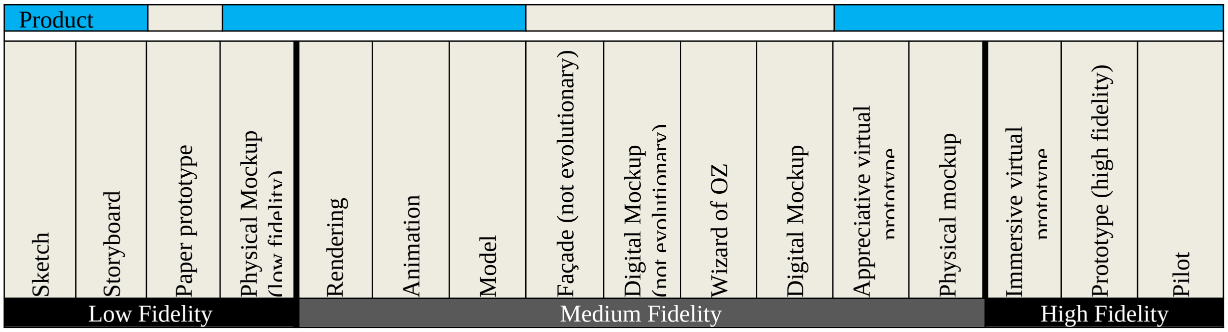


Figure 4 - Relation between design areas and the types of prototypes (source: the author)

We also classified the prototypes by its purpose of use in the design process: (I) Contextualization and Conceptualization, (II) Representation, (III) Development and (IV) Production. They can be defined as follows: (I) It allows contextualize the problem, the scenario, the market, the customer or product, or even define the preliminary concepts of the artifact that will be proposed for them. (II) It aims to present a project proposal to the other actors in the design process, (II) It has the objective of developing a generated concept and can evolve to the final proposal and (IV) It aims to test the productive aspects of the final proposal, evaluating the relation of the final proposal with the production technologies, quality, sustainability, viability, serializability, ...

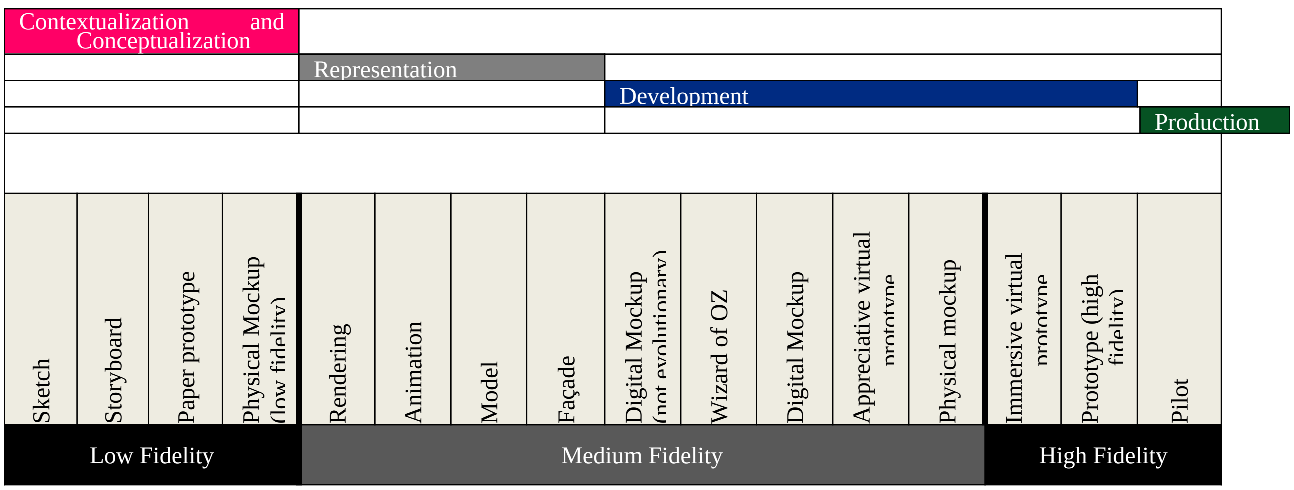
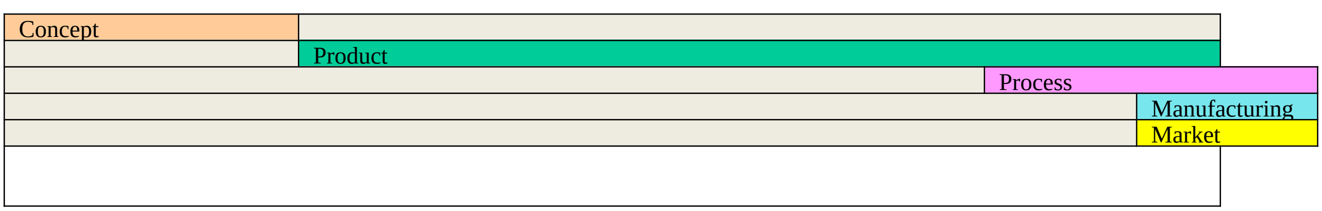


Figure 5 - Relation between the purpose and types of prototypes. (source: the author)

Ullman (2010, p.117) proposes and describes four classes of prototypes: concept prototype, product prototype, process prototype and manufacturing prototype, based on function and stage of product development. We add to this classification a new classificatory item, the market prototype. Based on that we could classify the prototypes according to figure 6.



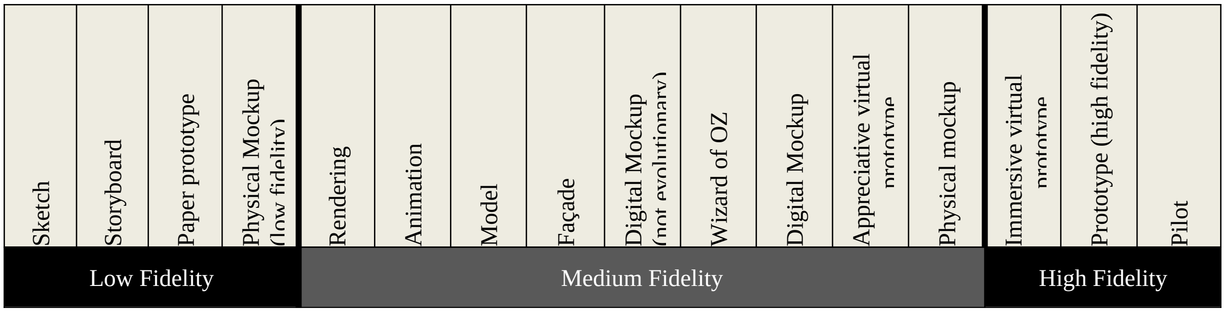


Figura 6 - Relação entre o propósito e os tipos de protótipos. (fonte: autor)

Budde et al (1992) define that prototypes can be characterized through stages of development. Each stage helps the designer to clarify the requirements defined in the project. They define three prototypes stages: (a) Exploratory, (b) Experimental and (c) Evolutionary. (a) Exploratory - should be used when the problem is not clear enough to define ways for the development of projective solutions, requirements of the future product and system, or even to recognize the true projective problem, (b) Experimental - should be used to the technical implementation of the product , i.e., including functional and ergonomic issues of the product and (c) Evolutionary - it allows to follow up the development of the product or system until the final product, i.e., through continuous iterative cycles monitored and evaluated until the product reaches the appropriate level of evolution. The prototypes, in relation to the stages, can be classified according to figure 7.

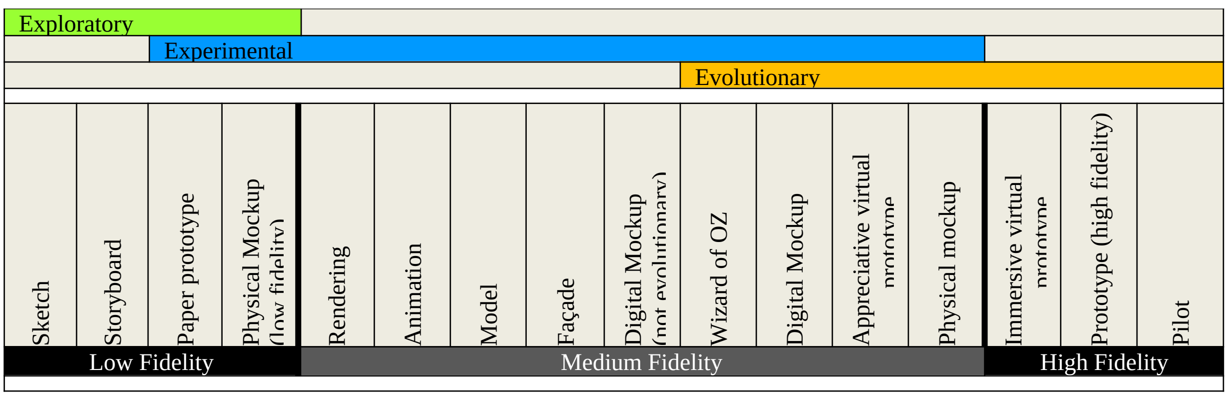


Figure 7 - Relation between the purpose and types of prototypes. (source: the author)

METHODOLOGY OF DESIGN MEDIATED BY PROTOTYPES

Methodology Construction

From the macrostages: Preparation, Development and Implementation, defined by the synthesis of methodologies from Assimov (1962), Gui Bonsipe (1978), Archer (1984), Loback (2001), Munari (2002), Cross (2005), Rozenfeld (2007), Baxter (2008) and Ullman (2010) and from the microstages defined by our theoretical basis of our study that places the prototype, the stages of design, construction and evaluation, and the iterative cycles, in the center of the design process, we developed a basic structure for the prototype-centered methodology (Figure 8). In that methodology we defined gates of approval in the passage of a Microstage or Macrostage to another, using as reference the studies of Concurrent Engineering (total design) of Purg (1990), the funnel of development of Clark and Wheelwright (1994), Phase Review of McGrath (1992), Stage-Gates of Robert G. Cooper (2011) and Maturity model of maturity Model (CMMI of SEI) and (OPM3 of PMI),

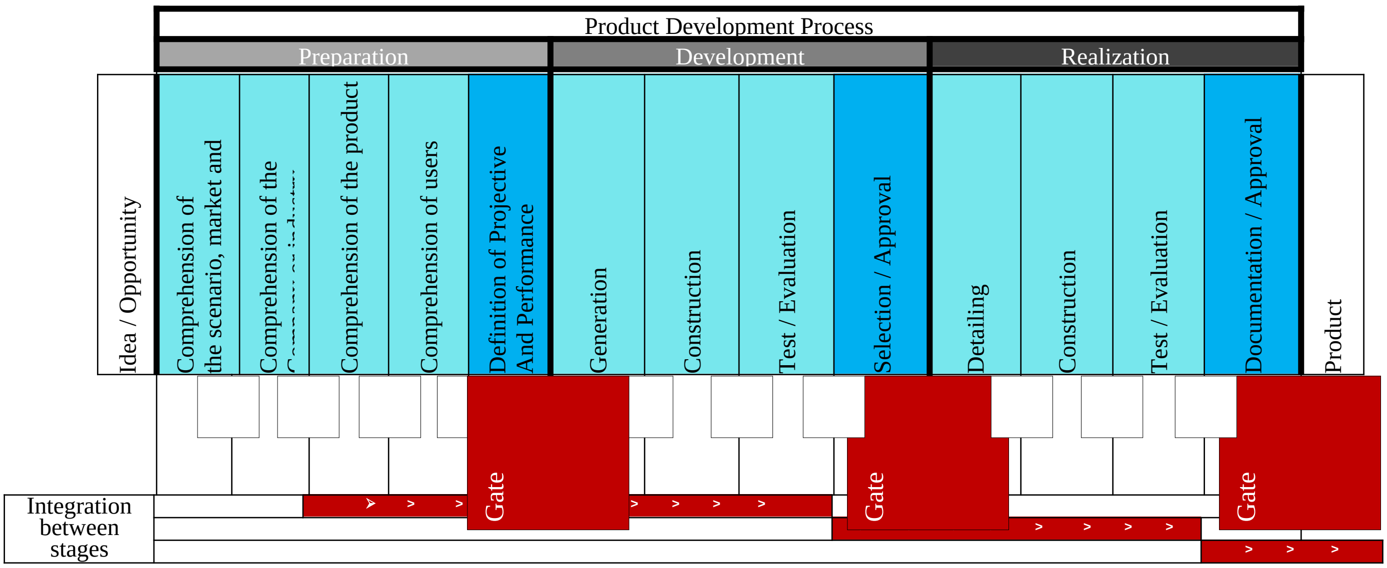
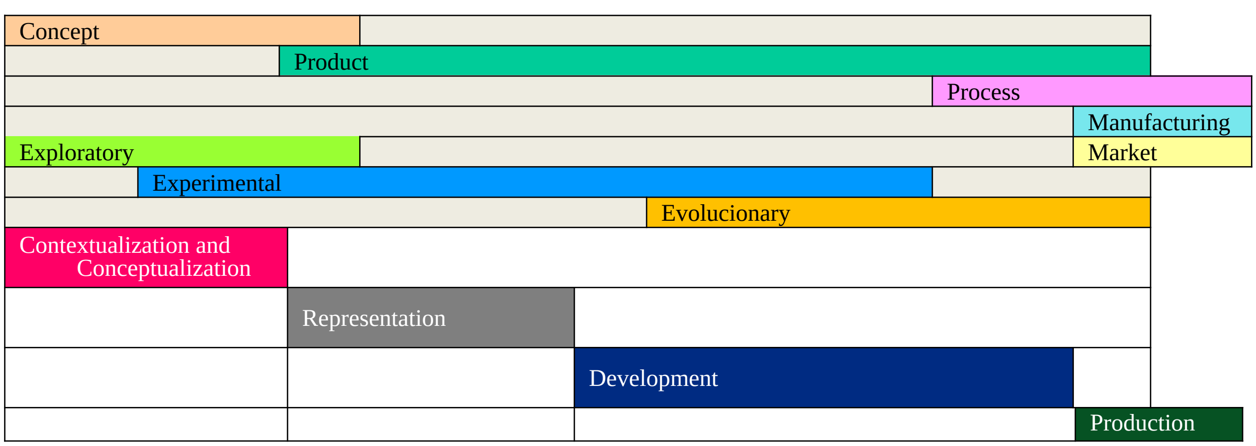


Figure 8 - Panel of macro and micro stages of the methodology mediated by prototypes (Source: the author)

In that panel, it should be evaluated the activities planned for that stage, compliance with the requirements defined in the initial stage, the alternatives that had the best performance and maturity of the final solution to make a decision with less uncertainty. Those gates can generate approval or return to previous stages to generate new cycles of development.

Methodology Tools

Based on the created methodology and the results of our study, we developed two tools to support the implementation of the methodology, selection of prototypes and conducting evaluations to assist the design in the prototype-centered design process: (a) Application for selection and evaluation of prototypes, (b) Worksheet for registration of requirements, weight, goals, results of evaluation and decision making, and (c) Cards of methods and techniques to guide the use of prototypes. The application selects the most appropriate prototype to each phase, design area, purpose, stage and intent of the design (Figure 10). It relates the communicative features and fidelity of the prototypes and with the features and activities planned for each macro or micro stage. To be used, the user (designer) just select the corresponding sequential items to what he/she wants.



Sketch	Storyboard	Paper prototype	Physical Mockup (low fidelity)	Rendering	Animation	Model	Façade	Digital Mockup (not evolutionary)	Wizard of OZ	Digital Mockup	Appreciative virtual prototype	Physical mockup	Immersive virtual prototype	Prototype (high fidelity)	Pilot
Low Fidelity				Medium Fidelity									High Fidelity		

Figure 10 - Full Panel of the methodology mediated by prototypes (source: the author)

At the end, the application displays the appropriate prototype and opens cards of methods and techniques that can be used for the application of the prototypes. It even helps to conduct the evaluation process and provides a spreadsheet for recording and monitoring requirements, weights, targets and results of evaluations carried out by calculating the best alternative and their level of maturity in relation to the goals to facilitate the process of decision making.

Experiment

Aiming to evaluate the results of the application of prototype-centered methodology, we structured a projective challenge between two teams of students of design, at Univ. Estadual Paulista (UNESP), located in Bauru, São Paulo, Brazil. The experimental team was trained with the proposed methodology and the other team (the control team) used the methodology that was taught and practiced at UNESP, based on some of the researched authors. The project of the experiment was submitted to the National Committee of Ethics in Research (CONEP) in March 2013 through Plataforma Brasil site, under the case number 14906713.2.0000.5398, and it was approved on April 24, 2013. All students who participated in the experiment signed a consent form that informed the objectives and terms of the experiment. The challenge lasted 8 hours, divided into 2 periods of 4 hours. The teams were composed of 6 students each and they developed the activities on consecutive days, the same structure was available for both teams: two laboratories of UNESP, one for traditional modeling of models and prototypes and another for use of new technologies of prototyping: Virtual and fast prototyping, with computers, software, 3D printers, milling and CNC routers, all drawing and modeling material and spaces for meetings and developing and evaluating alternatives.

Figure 11 - Experimental team developing the project during the projective challenge (source: the author)

The Briefing proposed the development of an innovative watch cell phone to the Swatch company, suitable to the needs of the scenario, market, company and users. The proposal was that they integrate into one artifact the knowledge of development of product and graphic design, and interfaces. Besides the guidelines of the briefing, users with the same profile of the briefing were presented to the teams, if they wished to collect information or evaluate the alternatives and generated products. That was important to assess the inclusion of users in both methodologies and processes performed by the teams.

Data collection occurred in the experiment: (a) by recording audio and video, through security cameras installed in all environments and through the D-view Cam software from the D-Link company, (b) through the manual registration of activities in intervals of 5 minutes made by 3 monitors and (c) through the photographic record with date and time synchronization. After data collection, all collected information was synchronized and it was conducted an analysis of the design process developed by both teams using 10 indicators previously defined and justified in our theoretical research. The indicators were: (1) Indicator of periodic monitoring of the PDP; (2) Indicator of inclusion and evaluation of parameters of the user and the scenario, (3) Indicator of use and suitability of the prototypes to the stages of the PDP, (4) Indicator of the division of problems into sub-problems. (5) Indicator of the continuity of the flow of activities in the phases of the PDP, (6) Indicator of costs in the PDP, (7) Indicator of the quality of communication, information management and decision making in the PDP, (8) Indicator of time in the phases of the design process, (9) Indicator of quality and viability of the product and (10) Indicator of phases integration of the design process. The structuring of the experiment data followed the methodology used by Griffiths (2004) and Gill (2005) that allowed generate various graphs to analyze the flow of activity and record each occurrence of indicators. Among the generated graphs is the general overview of the activities carried out by the teams (Figure 11). The analysis was performed from the comparative statistical graphs of quantitative data. Those quantitative records were generated from reporting incidents of those indicators throughout the development of each team activities. However, it was also performed a qualitative analysis based on the records of the monitors and the data from the audio and video system that allowed complement the analysis of the dialogues and activities developed by those teams.

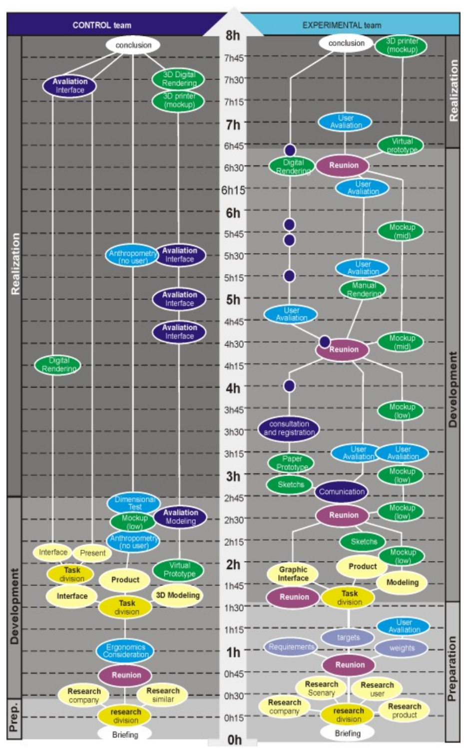


Figure 11 - Comparison of the synthesis of the general flowcharts of activities performed by the control team and the experimental team. (source: the author)

Results

The experimental team, using the methodology and tools proposed by themselves, got significant results in the: (a) Management of meetings for periodic monitoring of the PDP throughout the project development, (b) Realization of inclusions of parameters of the scenario and the users, especially in activities of: generation of projective requirements, definition of project concepts, realization of evaluations involving those users and the approval of the final product, (c) Use of a larger number of prototypes throughout the process, from the beginning of the project and in an appropriate way to each phase, stage and purpose of design, (d) In the process of communication between members and between users, information management of requirements and evaluations and decision-making, using the accompanying spreadsheet, throughout the whole challenge. Figure 13 shows the result of 10 indicators investigated. In that graph we see that the experimental team gets significant results in items: (1) periodic monitoring of the PDP, (2) inclusion and evaluation of parameter of user and scenario, (3) Use and adequacy of prototypes to the phases of the PDP; (5) indicator of flow continuity of activity of the PDP, (7) Indicator of communication, information, management and decision-making and (10) Integration among the phases of the PDP. From the graph we can see that the experimental team, in the total mean of the results, was 32.65% more efficient than the control team in the methodological process of design, and the overall results show a significant difference of performance in favor of experimental team, which applied the methodology proposed by our study.

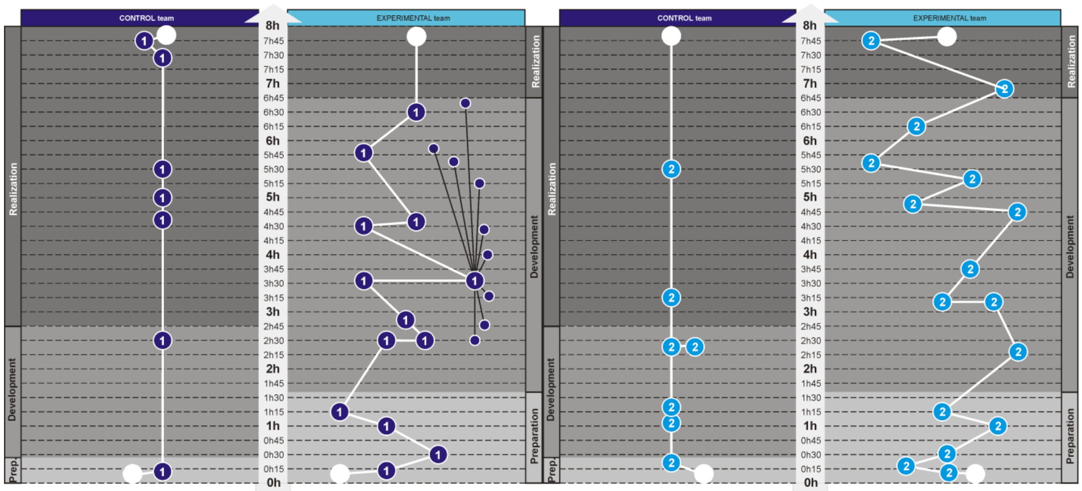


Figure 12 - Comparative Tables of results of experimental and control teams in the indicators of periodic monitoring and inclusion of parameters of the users, respectively, throughout the 8 hours of challenge. (source: the author)

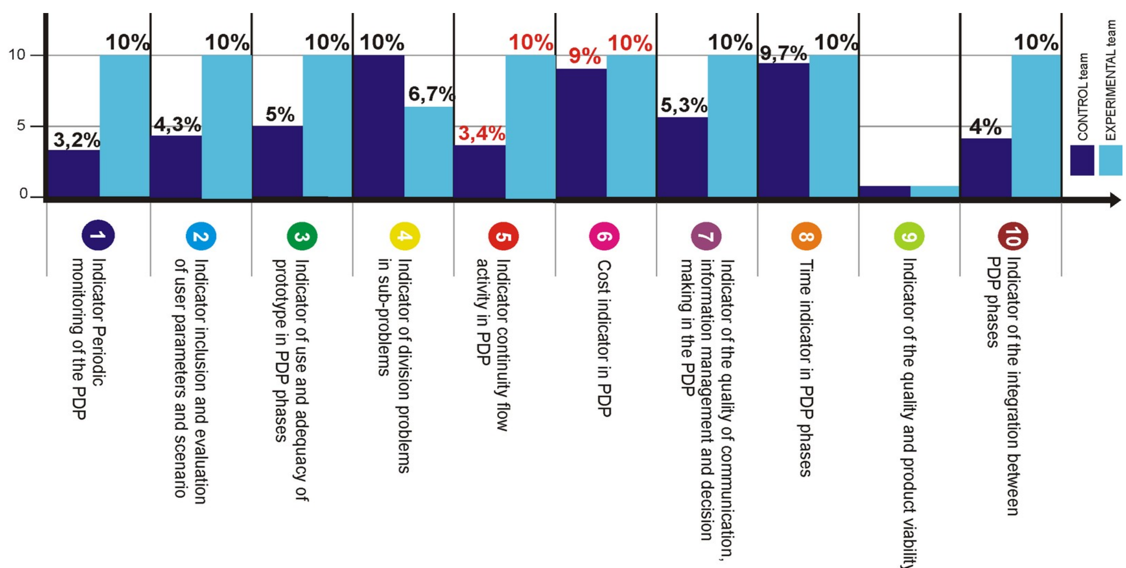


Figure 13 - Statistics of the performance of experimental and control teams in the 10 indicators (source: the author)

CONCLUSIONS

The proposed methodology was very efficient in important aspects of design activity: (a) inclusion of users in the design process, both in the early stages, to generate requirements, weights and goals for the project, and also to define concepts, parameters and carrying out evaluations of alternatives and the products generated; (b) use and adequacy of low, medium and high-fidelity prototypes, throughout the entire design process, helping to improve communication between the team members, the comprehension of the needs of users and the alternatives generated, and the realization of a greater number of evaluations that allowed to identify and select more precisely the best alternatives; (c) Management of the design and decision-making process, allowing to manage periodically the steps, register the requirements, weights and goals, and also monitor the results of evaluations in order to identify the best alternatives, the need to generate new iterative cycles with the use of prototypes and the right time to finish the project and approval of the final product, from the established goals and maturity levels. We believe in the principles that supported the prototype-centered methodology: (a) Make the design process more interactive, expanding the use of prototypes for all phases of the design process; (b) Realization of a larger number of iterative cycles using the appropriate prototype, considering the characteristics of the phases, the design area, aims, stage and purposes; (c) understanding the relation of those prototypes with time and cost involved for each prototyping technologies, adjusting the level of fidelity to each degree of uncertainty of the process, increasing the bets as this uncertainty is reduced throughout the phases and (d) Expansion of the vision of prototypes for something more than a tool for presentation of projects, realizing that they can contribute from the comprehension of the problem and what should be projected in the early stages of design, and also to find survey parameters with users, conducting evaluations with alternative and approval of the final product. We believe that those principles can help to make the design process and the products developed more efficient, believing that just as a child needs to interact with the world to develop better, a product needs interactive versions, i.e., it needs prototypes to evolve as we wish.

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