A MODEL FOR THE WEB-BASED COLLABORATION IN THE EARLY STAGES OF THE PRODUCT DESIGN PROCESS

Marcelo Gitirana Gomes-Ferreira
Núcleo de Desenvolvimento Integrado de Produtos (NeDIP – UFSC).
Campus Universitário, Florianópolis, Brasil. Caixa Postal 476. CEP 88040-900.
E-mail: gitirana@nedip.ufsc.br

Túlio Henrique Martins
Núcleo de Desenvolvimento Integrado de Produtos (NeDIP – UFSC).
Campus Universitário, Florianópolis, Brasil. Caixa Postal 476. CEP 88040-900.
E-mail: tulio@nedip.ufsc.br

Daniel Capaldo Amaral
Núcleo de Manufatura Avançada (NUMA – USP-SC).
Av. Trabalhador São-Carlense, 400, Centro, São Carlos, Brasil. CEP 13566-590.
E-mail: amaral@sc.usp.br

Fernando Antônio Forcellini
Núcleo de Desenvolvimento Integrado de Produtos (NeDIP – UFSC).
Campus Universitário, Florianópolis, Brasil. Caixa Postal 476. CEP 88040-900.
E-mail: forcellini@emc.ufsc.br

Abstract: *The early stages of the design process have a major influence in the success of the product. Final cost, quality and time-to-market are to high degree fixed at these stages of the product development process. A number of Web-based collaborative systems have been recently developed to support the final stages of the design process. A low cost Web-based collaborative system to support the early activities of the product design process is here proposed as a way to improve the competitiveness of small and medium-sized enterprises in the market. This paper presents an abstract model and a set of requirements for the ASCCP (Ambiente de Suporte à Concepção Colaborativa de Produtos), a prototype collaborative system intended to support the first activities of the product design process.*

Keywords: *Collaborative design, early stages of design, conceptual design, product development, machine design.*

1. INTRODUCTION

The major influence of the product development process – and of the design process in particular – on the success of the product and on the following competitiveness of the company in the market is today better understood. “Particularly the early phases of product development offer a large potential for development time reduction and for later product quality improvement… The variety of possible design solutions at the early phases, coupled with an often bad information quality, i.e. incomplete and unstructured tasks, leads to delays in development and negatively affects the product quality” (Schmidt and Feldmann, 2001). Figure 1 depicts the high impact of the conceptual design decisions on manufacturing productivity and product quality. According to Wang et al (2002), many manufacturing processes are indirectly determined at this stage. “The concept generated at this stage affects the basic shape generation and material selection of the product concerned. In the subsequent phase of detail design, it becomes extremely difficult, or even impossible to compensate or to correct the shortcomings of a poor design concept formulated at the conceptual design phase” (Wang et al, 2002).

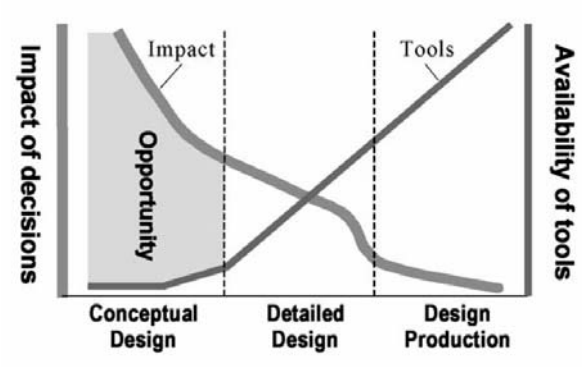

Figure 1. Opportunity in early design stage (Wang et al, 2002)

A number of Web-based collaborative systems have been recently proposed to support the design process. “The ability of the web for designers to combine multimedia to publish information relevant to the spectrum of the design process, from concept generation and prototyping to product realization and virtual manufacturing, motivated the adopting of the Web as a design collaboration tool. It is now playing increasingly important roles in developing collaborative product development systems” (Wang et al, 2002). Many of such systems focus on the late stages of the design process; others are still under proof-of-the-concept prototype development stage.

This paper aims to present an abstract model and a set of requirements for the ASCCP (*Ambiente de Suporte à Concepção Colaborativa de Produtos*), a prototype for a low cost Web-based collaborative system to support the early activities of the product design process. This collaborative system is proposed as a way to improve the competitiveness of small and medium-sized enterprises (SMEs) in the market.

2. COLLABORATIVE DESIGN

‘Collaborative design’ relates to the use of computer networks to support the group activities of the members of a product design team. Time and space (local) are the two dimensions frequently used to analyze design collaboration and the respective technologies – see Figure 2. Several kinds of collaboration may coexist inside in a company. Members of the functional departments may collaborate in projects. Collaboration also occurs along the supply-chains. People from the various stages of the product life-cycle collaborate in a simultaneous engineering environment.

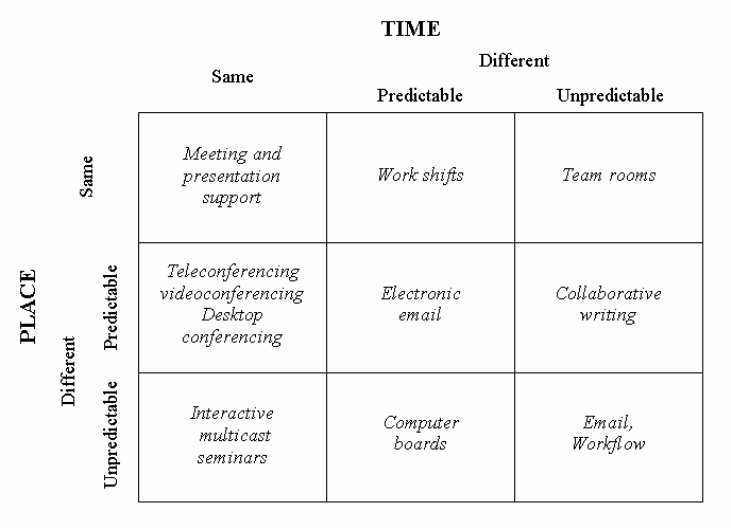

Figure 2. Dimensions of collaboration – adapted from Grundin (2002)

3. LITERATURE REVIEW

Work related to collaborative concept design in mechanical design process is sparse (Roy and Kodkani, 2000). Wang et al (2002) provide an extensive state of art review of existing research, projects and applications in the domain of collaborative conceptual design, based on the Internet and Web based technologies. 'Agent technology' and 'Web-based technology' are highlighted among the diverse emerging technologies that have been proposed to implement collaborative systems. Roy and Kodkani (2000) present an approach to support geographically dispersed designers in the development and selection of product concepts. Their approach has a great merit in the use already available tools from the Internet that, in alliance with customized tools, specifically tackles issues related to product conceptualization. Schueller and Basson (2001) introduce the DiDEAS (Distributed Design Assistant), a collaborative system to support a distributed team of designers. This system stands out by its tools for communication, information transfer, and design content input. Huang et al (2003) have developed the ProDefine, a system created to support early product definition. It offers four main front-end components (application clients) and two back-end databases.

ASCCP takes advantage of the several good aspects of the above mentioned collaborative systems and approaches, but a better support to the informational design and the functional analysis in the conceptual design is pursued. Modularity and more flexibility in the use of its resources are also important aspects to be implemented.

4. THE MODEL

Three complementary segments form the model, based on which the ASCCP system is being developed. The 'application' segment provides specific design methods and tools to be used along the stages of the informational design and the conceptual design. Technical, and also managerial applications, are to be implemented in the system. The 'communication' segment makes synchronous and asynchronous communication possible among the members of the design team. This segment should support not only to dialogs and massages between designers, but also the exchange of all sort of design related documents, such as requirements, comments and sketches. The 'knowledge base' supports the design team with different kinds of design knowledge: useful links, experts, sources of good ideas, patent bases, and so on. A well established 'design methodology' serves as a background for the development of the above mentioned segments – see Figure 3.

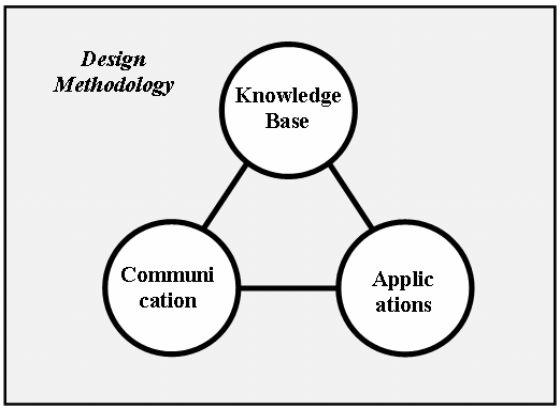

Figure 3. Abstract model for the ASCCP

5. THE DESIGN METHODOLOGY

Models of the design process have been developed since the early 1960's. In engineering design, this development seems to have converged into a phase model, comprising four phases (Roozenburg and Eekels, 1995). In Pahl and Beitz (1996) terminology such phases (or stages) are called: 'clarification of the task', 'conceptual design', 'embodiment design' (or 'preliminary design') and 'detail design'. Emphasizing the importance of the full analysis of the design problem (and related requirements) to the final quality of the product, Fonseca (2000) denominate the first stage of the design process 'informational design'. Informational design and conceptual design represent together the 'early stages of the design process' – see Figure 4.

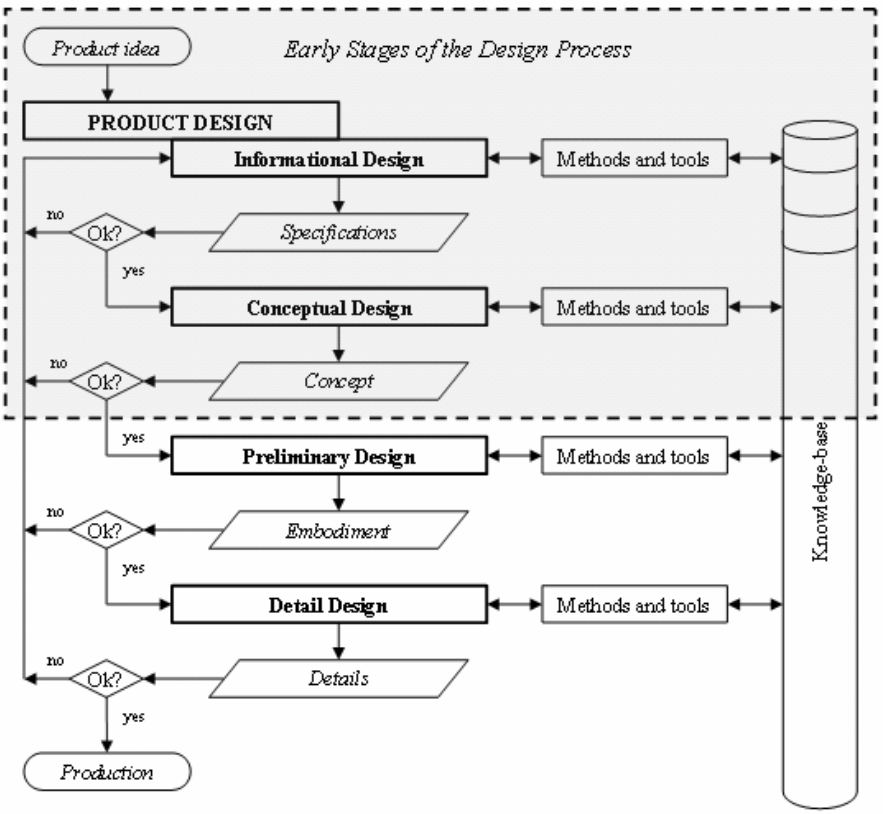

Figure 4. Early stages of the design process

The informational design, first stage of the product design, aims at developing the design specifications, starting from a set of consumer needs. Such specifications usually take the form of a list of goals to be achieved by the product under development. The design team will exploit the specifications in order to define the required functions and properties for the product, as well as the constraints related to the product and also to its design process.

The conceptual design is the stage of the design process where a concept for the product is developed, starting from the design specifications. A concept is an idea that can be represented in a rough sketch or with notes. Conceptual ideas are abstractions of what might someday be a product (Ullman, 1997). The concept should satisfy in the best way the needs of the customers, taking into account the limitations of resources and the constraints of the design process. “Conceptual design is commonly seen to be the most important phase of the design process, because the decisions made here will strongly bear upon all subsequent phases of the design process. A weak concept can never be turned into an optimum detailed design, so to speak” state Roozenburg and Eekels (1995).

Based on Fonseca (2000) and Pahl and Beitz (1996) methodologies, Figure 5 shows the several steps of the early stages design methodology used by ASCCP.

6. REQUIREMENTS

High speed, reliability, accessibility (user-friendly interface) are among the many requirements which determine the effectiveness of a system on the Web. In the following, we identify some wishes and demands, related to the issue of collaborative product design, that are guiding the work on the development of ASCCP.

Low cost hardware components

In order to be actually accessible to small and medium sized enterprises (SMEs), a collaborative system should make use of low cost hardware components. The intent is to take advantage of the already existing resources of the company: personal computers and low cost peripherals. Figure 6 illustrate some typical hardware components that are being tested on our collaborative design experiments: web-cams, headphones, tablets and scanners.

Compatible bandwidth

It is necessary to be very conscious about the bandwidth limitations that the companies will have to cope with when using the collaborative system on the Internet. The bandwidth issue becomes even worse in underdevelopment countries, such as Brazil, as confirm Figure 7.

Use of available tools and resources in the Web

Instead of reinventing the wheel, the purpose of ASCCP is to exploit as much as possible the already existing tools and resources already available in the Internet. This is particularly valid for the communication segment of the system. As said by Roy and Kodkani (2000): “There are several tools available on the WWW to support collaboration such as conferencing tools, whiteboards, etc. These could be utilized in alliance with customized tools developed for the WWW, which specifically tackle issues related to product development”.

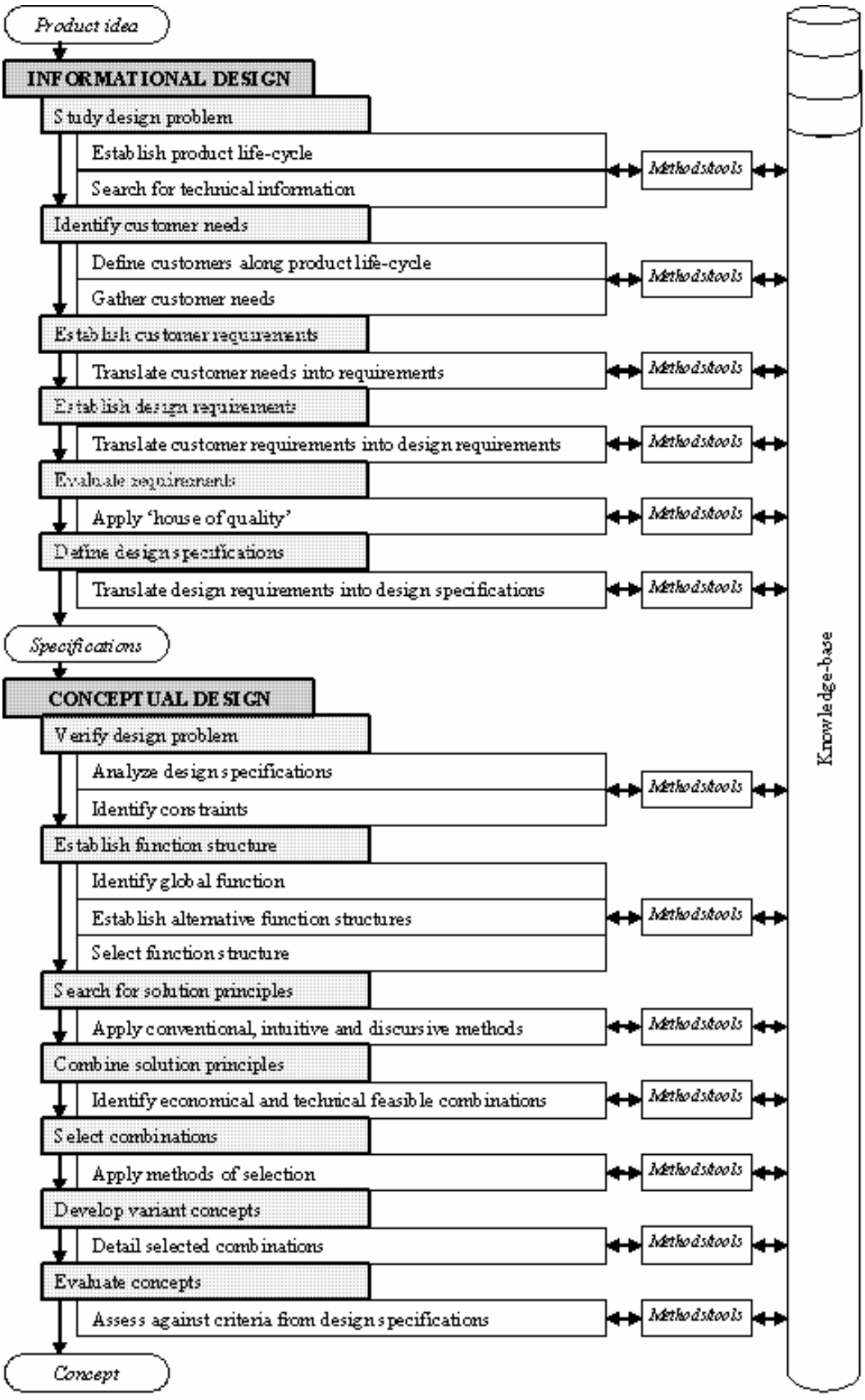

Figure 5. Early stages design methodology – adapted from Forcellini (2003)

Figure 6. Low cost hardware components for a collaborative design system

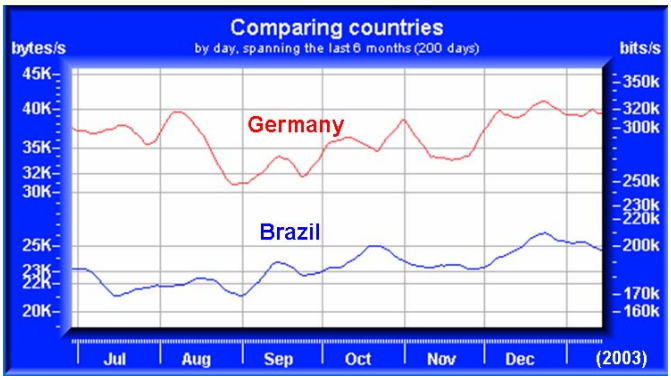

Figure 7. Comparing the average speed of the Internet in Brazil and Germany (source: http://www.numion.com/YourSpeed/)

Better support to informational and conceptual design

Although the ASCCP is intended to support the whole activities of the early stages of the design process, special attention should be given to the activities of the informational design, and also to the preliminary activities of the conceptual design, the ones related to the functional design of the product. Such activities are not fully supported by the systems discussed in the literature review. Figure 8 illustrates the lack of support tools addressed to the needs of these earliest stages of design process.

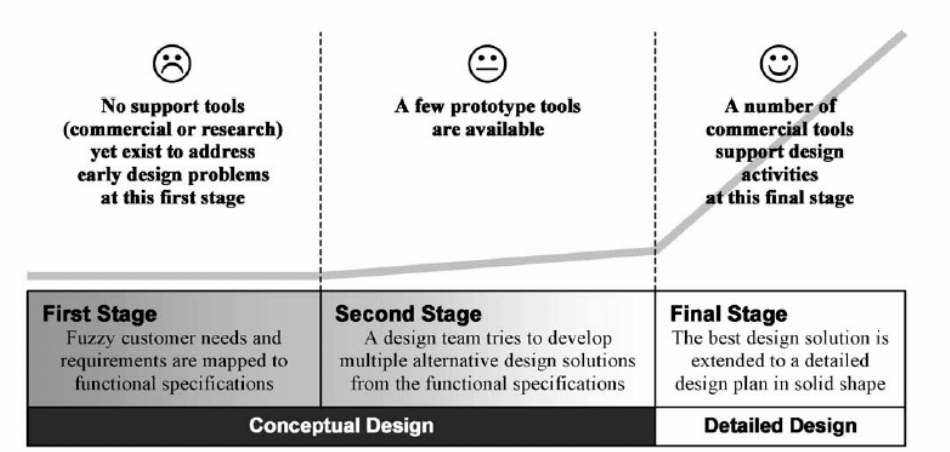

Figure 8. Availability of design tools (Wang et al, 2002)

Use of innovative methods and tool

The system should not restrict itself to the use of well established design methods. That should be regarded as opportunity to work in a collaborative way with new and innovative design techniques. For instance, 'DSM', 'IDEF0', and 'Petri Nets' may possibly be used instead of PERT to represent the activities of the design process (managerial aspect), and also to model the structure of the product under development instead of a tree structure (technical aspect).

Support technical and managerial aspects

The ASCCP should to support the designers not only in the technical aspects of the design process. As stated by Bruce et al (1995): "It is clear from the survey that collaborative product development needs to be treated more critically than at present, … Attention has to be given to managerial and other factors that influence the outcome of the collaborative process".

Independence of platform

This demand was achieved when we chose to implement our collaborative system on the Web. No matter if you use the MS Windows or the Linux as your operational system, all you have to do to use the system is to access its site in the Internet; no matter if you use the MS Explorer or the Netscape as your Web browser (in fact, there are a few problems related to browser incompatibility that we still have to cope with).

Remote access

The Web also provides the user with remote access to the collaborative system. There is no more need to install any program at your personal computer; again, all you have to do is to access the appropriate site in the internet.

Modularity and expandability

Complementary modules of applications, knowledge-bases and communication channels should compose the collaborative system. Such modularity eases later adjustments and the expandability of ASCCP.

Integration and independence of applications

The applications provided by the collaborative system should work in an integrated manner. This integration is attained through the use of compatible product models. A tool developed to perform the functional analysis of the product should deliver a list of functions that could be automatically used by the application that was developed to help the designers in the search for solution principles, for instance. Although integrated, the applications should be developed to be also used independently. The designers should feel free to choose the most appropriate tolls, according to their needs.

Independence of design methodology

At last, although a well accepted design methodology is used as a background for the development of ASCCP, this scheme should not be imposed to the design team. The resources provided by the system should help the collaborative efforts of the designers, no matter on which design methodology they base their work.

CONCLUSIONS

An abstract model and some requirements for a Web-based collaborative system to support the early activities of the product design process were introduced in this paper. The Web, and its related technologies, presents a great potential to promote the collaboration among the members of product design teams in small and medium-sized enterprises (SMEs). More intensive, synchronous and asynchronous, collocated and distributed, collaboration should result in better and less expensive and more competitive products launched in the market.

Better support to the informational design and the functional analysis, in alliance with a more modular and flexible architecture, are some distinctive characteristics to be pursued in the development of the ASCCP – a collaborative product design system under development at the Federal University of Santa Catarina (UFSC), in cooperation with the São Paulo University in São Carlos (USP-SC), in Brazil.

REFERENCES

Bruce, M., Leverick, F. and Littler, D., 1995, "Complexities of Collaborative Product Development", Technovation, Vol. 15, No. 9, pp. 535-552.

Fonseca, A.J.H., 2000, "Sistematização do Processo de Obtenção das Especificações de Projeto de Produtos Industriais e sua Implementação Computacional", Dr. Thesis, Federal University of Santa Catarina, Brazil.

Forcellini, F.A., 2003, "Projeto Conceitual", NEDIP, Florianópolis, Brasil, 154 p.

Grundin, J., 2002, "CSCW: History and Focus", University of California, United States.

Huang, G.Q., Lee, S.W. and Mak, K.L., 2003, "Collaborative Product Definition on the Internet: a Case Study", Journal of materials processing technology, Vol. 139, pp. 51-57.

Pahl, G. and Beitz, W., 1996, "Engineering Design: a Systematic Approach", Springer, London, United Kingdom, 544 p.

Roy, U. and Kodkani, S.S., 2000, "Collaborative Product Conceptualization Tool Using Web Technology", Computers in Industry, Vol. 41, pp. 195-209.

Schmidt, J. and Feldmann, D. G., 2001, "A Web-based information tool for application engineering", Proceedings of the 13th International Conference on Engineering Design, Glasgow, United Kingdom.

Schueller A. and Basson A.H., 2001, "A Framework for Distributed Conceptual Design", Proceedings of the 13th International Conference on Engineering Design, Glasgow, United Kingdom.

Ullman, D. G., 1997, "The Mechanical Design Process", McGraw-Hill, New York, United States, 337 p.

Roozenburg, N.F.M and Eekels, J., 1995, "Product Design: Fundamental and Methods", Wiley, Chichester, United States, 408 p.

Wang, L. et al, 2002, "Collaborative Conceptual Design – State of the Art and Future Trends", Computer-Aided Design. Vol. 34, pp. 981-996.