Cross-functional teams and concurrent engineering: contributions to the development of product design through multidisciplinary integration using CAD systems

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Abstract: The existence of well-defined patterns constitutes an efficient strategy for the creation of integrated teams working jointly to make successful product development possible. Spearheading such efforts, computerized design support systems such as CAD (Computer Aided Design) offer an alternative for the establishment of the concept of cross-functional work teams which reduce communication problems that are often at the heart of high rework indices. Such computerization can provide adequate support for the implementation of development methodologies such as Concurrent Engineering. This paper presents relevant points aimed at contributing to underpin decisions involving the construction of integrated environments in cases where Cross-functional Teams, Concurrent Engineering and computerized design support systems are under dispute. The method applied in the development of this research was a case study of a methodological strategy employed at an auto parts manufacturer.
Keywords: cross-functional teams, concurrent engineering and computerized systems

1. Introduction

The development of new products is full of uncertainties referring in such a way to the new technologies to be used and the expectations of the market for these products. When the new products involve high levels of technological innovation, a significant difference sprout between the amount of necessary knowledge for the development of a new product and the amount of possessed knowledge already for the organization (SWINK, 2000). In these cases, unless exists a great number of experiences on last projects that can be taken as base, the difficult on anticipated identification of problems will be increased and the members of the cross-functional teams will depend even more on the specific knowledge of other specialists. This implies the necessity of facilitation of the access to the information, demanding a bigger integration of the organization.

The benefits of the process of integration in product projects become more visible in more advanced stages of the project, justly for the adoption of methodologies and tools that contribute in the prevention of problems (as Concurrent Engineering, strategies of Front-Loading, CAD Systems). Despite contributing for the reduction of future uncertainties and increase of the integration process, the implementation of that cause a dilatation of the time in the initial stages of project. An example of this would be new incremental products – "*characterized products as being extension of a line already existent*" (MASCITELLI, 2000) – where the information is already dominated by the members of the teams and the economy of time in the development of the product not always justifies the increase of the time in the phases of implementation of integration tools (SWINK, 2000).

The new involved technologies in the project activity associates to the techniques of simultaneous development had brought benefits to the process, a time that had contributed for the increase of the flow of information between the involved ones, making the distance less evident and the communication level better qualitatively. The intensity of data exchange, now facilitated for the computerized systems, contributes for the enrichment of the project activities, becoming viable the anticipated solution of problems in the initial stages of project. Therefore, an early identification of the problems in its origins improves the relationship among the teams and the different sectors, because the volume of inconsistencies is replaced to the following stages is diminished significantly.

2. Cross-functional teams, concurrent engineering and CAD: contributions to the integration for the development of product projects

The development of products, in the current context, has demanded processes of conception and production faster and integrated, as a way to reduce the costs and the levels of rework

(KUSAR et al., 2003). For this, it was observed the necessity of a fast and efficient transference of information among some organizational levels, as well as among the different sectors and the groups that are involved with the product. The flow of information, a characteristic of the parallel work among different teams, can be facilitated by the adoption of Concurrent Engineering (CE):

"*Concurrent Engineering is a philosophy that has emerged in the last decade in a feedback to growing pressure to reduce costs and lead times while improving product quality. CE is defined as a systematic approach to paralell development of all product life-cycle activitie, from inicial conception through desing, planning, production and disposal. It presuposes a enriched infrastructure which is unconstrained by geogaphical location and encourages right-first-time methods through cross-functional team working and consensus*." (HANNEGHAN et al., 2000).

Diverse authors (as PRASAD, 1999; HANNEGHAN et al., 2000) have demonstrated that the use of work methodologies by parallel development, adopted in CE, needs the Cross-functional Teams (CT) as previous stages of its implementation. These teams are defined as:

"*Group formed for professionals of diverse specialties as Product Planning, Concept of the Product, Product Project, Prototyping, Manufacture, Assembly, Product Planning Engineering, Control and Administration, Distribution and Technique Assistance, being each one of them responsible for including the aspects of the product that compete to it, having conscience of the activities of the other participants and the stated periods to be fulfilled*" (PRASAD, op. cit.).

From the adequate set of these elements (CE, CT), it is perceived that it is possible to improve the flow of information and, consequently, the way to how resolve problems related to the development of product project. The anticipation in the detention of project problems also becomes possible, it can be able to reduce in up to one hundred times the project costs (THOMKE & FUJIMOTO, 2000). However, this is not a simple task, therefore it demands the formation of teams highly structuralized, in which the multidisciplinary experience represents an advantage for adding value to the product, through of more refined definition of the attributes that this must possess. The use of work groups with these characteristics allows that the different experiences offer varied solutions for one or more problems. When the solutions appear in initial stages of the development, it become more evident the shortening of the time expended in some procedures, what it contributes to attenuate or even to eliminate errors in more advanced stages of development, favoring the anticipation in the launching of products in the market.

In research carried out for SHERMAN et al. (2000), it is perceived that cross-functional teams represent an important form of integration, mainly between R&D (Research and Development) and Marketing, therefore can influence in the time of the cycle of development of products. The reduction of the development time has represented a strategic differential among companies ahead of the competitiveness increase. However, the companies must be considered that the technological level of market environment where they are inserted, because how much bigger the technological requirement of the market in relation to a product project, more critical will be this time. Especially in environments where the technological level is high, the improvement of the process of communication among the individuals, sectors and even among different companies, becomes a determinative factor for the success of the work and it can strongly be supported by the use of computerized systems, especially in the process of project development, in which tools as CAD (Computer Aided Design) are used. The CAD is, on an ample way, a multidisciplinary technology, a set of tools used by all the areas in which there is an integration of the digital computer to the activity of project, as well as to the control and management of this process.

It is convenient to say that the adoption of equipment or software that support to the project activity without the adjusted preparation for its implementation can mean the mere acceleration of an already existing procedure, instead of representing a profit for the company. However, it is perceived that the potential represented for tools CAE/CAD is very beyond prompt forms of acceleration the previous process, as the automatic generation of drawings. In contrast, it can be said that the real benefits for the company are associate to the improvement of the results of the project in quality terms, as reduction of verification and compatibility errors, elimination of important stages, as the reduction of the number of prototypes, etc. These activities, crucial for the success of product project, depend on a refined interaction among the members of the project team and among the other teams involved in the processes linked to production. In this case, CAD can represent an effective instrument of integration and support to the parallel accomplishment of stages of product project, a typical aspect of the CE. By the way, most of literature on CE establishes narrow relation between this and the adoption of systems CAD.

On the other hand, one of the conditions for the adjusted adoption of systems CAD is the effective standardization of the procedures supported for the tool, without which it becomes impracticable, in it practices, the adjusted circulation of the information. Therefore, one becomes excellent the creation of internal mechanisms the company for the formalization and standardization of the existing procedures in each sector (MATTOS, 1991; HARTSON, 1998). This makes possible a better agreement among the involved ones at the different stages of development, therefore each individual will know, in principle, the way to be covered in each activity without that it has that to create alternative and unknown ways from the others members of projects and manufactures sector. This formalization, besides leaving the passage of the information to involved ones clearly and evident, allows that the work environment becomes more collaborative.

In this way, a difficulty to be faced in the formation of cross-functional teams is on barriers to a effective integration, that can be classified in different types, as technological, interpersonal, organizational and physical barriers (GRIFFIN & HAUSER, 1996). During the implementation process, it was observed some organizational barriers that can be related to the way as the involved agents interact between themselves. These barriers cannot be linked only on the individual factors, but also to the predominant paradigms of the companies, who privilege forms stanch of work, or too much segmentation. In these cases:

"*The development of informal cross-functional teams can assist in the reduction of the barriers of language, thought and physics for the integration, improving the information to be transmitted and used, increasing the coordination and decision taking and diminishing the project uncertainties, directing to a bigger success in the income goals, profit and in the launching time*" (GRIFFIN & HAUSER, op.cit.).

3. The importance of the management support to the integration process

The approval for the development of a determined product is given, generally, by the high administration of the organization, falling again on the subordinated departments the responsibility for the advising technician for product project and production viability. Thus, everything what involves strategic questions or adoption of new

work methodologies needs authorization of the administrative staff or the executive director of the company. It is observed, therefore, that the support of the high step is determinative for the success of the implementation of any strategy that involves the purchase of computational tools as well as the adoption of new work methods for the product development projects. "*An relevant support of the high administration, mainly on the development of new products, is associated with the reach of objectives in relation to the time development, product quality and optimization of the financial resources*" (SWINK, 2000).

The support of the type "top-down" (or from high administration to lower levels) in a determined project demonstrates to the involved ones seriousness, importance and commitment from the high administration, generating a bigger enthusiasm and personal involvement of the participants. "*The development staff who perceives a high level of commitment and priority of the managers, has greater probability of becoming more interested on the project, taking greater ownership feeling, and to be more made use to run risks*" (SWINK et al., 1996).

During the planning for the product project, some requirements such as the analysis of the technique and financial viability, plant capacity, human capital and tool rack are necessary, beyond the definition of the characteristics of the proper product. Ahead of this, it is noticed that some other factors are shown, beyond the requirements of the customer and the singularity of each project. These factors must be in tuning with the profile of the members of the cross-functional teams, especially in if treating to new platforms. Platform of products can be defined as being "*a combination of subsystems and interfaces that makes a common structure of which a gamma of derivative products can efficiently be developed and be produced*" (MEYER & DALAL, 2002).

It was also observed that, as the evaluated aspects can vary from product to product, in special if the platform of such projects development will not be the same one, the necessary abilities to its development also can vary. This means that it is very important, during the stages of work planning, the definition of the necessary abilities to the cross-functional team constitution. For the formation of the groups the necessary abilities in each stage of the project must be considered, as well as the unfoldings of the product throughout its cycle of life. The people who will constitute the team must be chosen to make possible the alignment of the professional profile with the requirements specific techniques of each project, as well as the experience with last projects.

GAO et al. (2000) affirms that the cross-functional teams are capable to contribute for anticipated identification of the difficulties and problems that the project can present. The existing cross-functional in these groups prevents that the rework problems occur more frequently in the end stages of development, mainly because revisions with bigger criterion in the initial stages are made, in view of the participation of staff liked to the production stages, for example.

4. Research

Focusing on the purpose of detaching the improvements gotten with the implantation of some principles of the CE, it was made a research in an industry of the automotive components segment. This industry has approximately 900 employees and its main customers are companies as GM (28%), FIAT (30%), FORD (14%), VW (11%), "after-market" or retail (7%) and others (9%). Due to requirement of the customers for the improvement of the quality and to the market transformation suffered, the company was lead to get certification ISO later the 9000:2000 and TS - BVQI (Technical Specification - Bureau Veritas International Quality). These certifications had been primordial therefore the company could obtain a high formalization index of its procedures, important aspect for implementation of the CE.

About 30% of the projects that are developed in co-design with the customers, that is, the searched company is responsible for an important part in the product development of the customers, going beyond the translation of the technical specifications of the drawings. It also offers compatible solutions of design with the concept of the product established for the customer. The average time of project development is tied with the time of launching of the vehicle in the market, approximately 2-2,5 years. To the others 70% of the projects, the company is responsible like a Contracted Manufacture (CM), receiving the technical characteristics from the drawings already defined by the customers, being responsible only to elaborate the project in CAD system to adjust it the internal procedures of the company. It is important to say that it was observed a sufficiently superficial use of CAD system, being used only as drawing stations, what it represents a wastefulness of the potential presented for the tool.

Before the certification and the CE, there was not responsible team exclusively for the function of projects management; this coordination had being position of the development proper engineers. This had demanded an effort exaggerated for parts of these professionals, when carrying through activities that were not of its sphere of ability. Thus, they finished forced to dedicate to the company a superior time very to formal regulated. Despite this effort, the reached results had remained on this side of the waited one.

With the certification, the organization started to use some tools and methodologies related to the systems of products development in strategic level (for the company as a whole) and operational / project: Stage Gate Systems, Cross-functional Teams, Prototype Test Cycle and Concurrent Engineering, beyond the Continuous Renewal of Platform. One another interesting aspect is that the company started to appeal the previous projects as a way of enrichment and exploitation it accumulated organizational learning.

The recurrent formalization from certification, at the same time that allowed the company to have a bigger domain on the way to act of the employees, it also contributed to implement some principles of Concurrent Engineering for the accomplishment of its works in co-design with its customers and, mainly, for the formation and coordination of cross-functional teams.

For the development of any product, either in co-design or as contracted manufacture, currently the first step of the company, after to receive the concept from the customer, is the formation of the cross-functional teams. These teams are defined in accordance to the type of product that will be developed, looking for always to line up the profile, the abilities and the experiences of each member of the team with the requirements of determined project. Members of all the departments, without exception, constitute the teams.

As well as the customer it defines a concept of its end item, the searched company also elaborates a concept for its product (component), based in the necessities of the customer, so that the final form does not intervene with the shape and functional characteristics of the automobile. This concept is defined by the formed cross-functional group, which in a posterior stage to this will make the test of this concept with the simulation in CAD and, in the same program, to verify the sizing and the simulated test of the functionality. After this stage, has broken for the assembly of the tools and necessary matrices to the confection of the tools standard for injector, respectively. It is important to only mention that all the processes of development

of the projects and the processes are defined by the Engineering of Projects and, later, replaced to Manufacturing.

Using a relation of priorities, the cross-functional team get to define the goals and tools that are necessary during the development, if it will be necessary to sub-contract another company to develop the tools, stage that does not exist inside of the company. Thus, it occurs the generation of a document, in which is planned all the necessary accomplishment steps to the works. Inside of this scene, the meetings of the team are made three times per week, independent of the type of in progress project (co-design or contracted manufacture).

Throughout all the project development, the professionals of industrial manufacture, quality and engineering are permanent. The others professional ones have participation only during parts of the project, when their specific knowledges are demanded. The participation of a member in a project does not exclude its participation in others, they can be inserted in more than one cross-functional team. It is still relevant to show the manager role of project sector that, using the Stage Gate Systems process, establishes meetings on the end of each stage of the projects for procedures verification. Thus, the conformity of the product is evaluated and when problems are identified, it is defined a plain alternative of control for the same ones.

However, evaluating the projects sector of the company, it was observed that there are four graphical stations with CAD systems, being a license of UNIGRAPHICS NX™ (UGS™) and three licenses of software CATIA™ (one is IV version and the other one is V version). With the existing computers in the projects sector, it is possible to establish a communication between the designers through to CAD systems, which each one has access to the archives of the other; not having limitation to the access of the information between these professionals. This existing integration between the designers allows they help themselves mutually in the development of same project when it is necessary. However, there is no CAD system in the others departments, unless to a visualization way, so that the dependent subsequent stages of the works of the projects sector, could monitor or even offer suggestions for definitive procedure that came to intervene with the activities of the destination sector.

Inside of the context of the studied company there is not a computerized system, beyond the Intranet, that allows integration among the projects sector and the others. The best tool of integration used by the departments is the project cross-functional team. Inside of these teams, there is a constant exchange of information, by "face-to-face", official notices internal of the company or email, beyond partial reports that make possible the constant verification of the status of course of the projects.

5. Conclusion

The substitution of the traditional methods for computerized systems brought advantages for the project sectors of the searched company. However, it becomes necessary to understand the different ways to use and interact these systems with its direct and indirect users, fitting to they to identify the procedures of tool application more adjusted to the work that has being developed. The use of CAD systems admits the collaborative work environment creation, since it allows the sharing of information of project among different stations of work, but the stations must have compatible software. However it implies, at the same time, in the using of formal instruments for the standardization of the procedures of the users. It can be said that the creative process involved in the project, as well as the abilities related to the product, remains necessary and important aspects to the products project. The main contribution is about the possibility of a effective integration among the different actors involved, as well as in the participation of a bigger number of different professionals in the team. However, for that this participation be effective, it is crucial that the common language and procedures have an adequate degree of standardization. Without this standardization, the team can become into a " Babel Tower ", in which few can understand themselves. On the other hand, an extreme standardization can lead (as frequently it occurs) to the " rigid " of the process or, what is more common, the diverse strategies for non-observance of the norms (certifications) prescribed.

After the research be concluded, it is perceived that the formalization of procedures to the activities of project precedes the implantation of the CE and must be used as method of orientation of the activities of the cross-functional teams, which needs the standardization of definitive common procedures so that its participants know with precision the sequence of the work before execution. The research demonstrated that it is not adjusted that a group or team executes its activities of random form, or in the way that understands as more convenient, without that the other groups be involved. The structuralized procedures must be in this form in way to function as "common language" between the teams. The balance between the characteristics and real necessities of each activity and the formal procedures defined by the searched company must be the main objective to be considered.

Considering this balance, still that partial, was the most part responsible for the relative success of the implantation of principles of the CE in the searched company and the integration of this with customers and suppliers. The sharing of project data is wronged for the superficial use of CAD tools in the studied company, which is not used by all the involved sectors in the project and it does not possess specifications of use come back toward CE applications.

The formation of cross-functional teams constitutes the first step for the implementation of the methodology of Concurrent Engineering, but so that the groups can be managed of integrated form, the formalization of some routine procedures of the organization becomes necessary. Such formalization involves the detailed analysis of the forms of individual work and collective, involving the characterization of the flow of information among individuals and sectors, identifying if the transference of the generated knowledge occurs in satisfactory way. In the truth, the formalization represents a way to lead the works of the team, establishing an efficient communication between the members of the team using the common language. When the procedures standard, formally established by a company, reflect the real procedures, executed by the professionals, it is verified that the individuals and the environment are interacting in tuning. As much the average management and the high administration will be proven that what occurs in the practical one reflects what it is registered. A time fulfilled these aspects, it can be affirmed that the organizational environment is prepared to manage the work in team of integrated form, also being able to launch hand of computerized systems of support to the project.

Analyzing the organizational context, it is observed that the changes in the environment of the studied company are not always well received because they imply in the alteration of certain habits and cultural aspects already consolidated by the standardized individuals and for the proper company. The transformation process aim at the elaboration of one consistent politics of integration that establishes a formalization of the procedures of the project activities and related sectors. Thus, the adoption of formal methods in the activities of the designers allows the universalization of the communication language, diminishing the level of interferences that can appear from the cultural differences and the different levels of knowledge.

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