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ABSTRACT

In modern society, a company's competitive advantage is directly related to its capacity for product development. This paper describes the use of a Model Integrated Factory to simulate product development business processes for the education of engineers. (WRM)

Teaching Scenario Development for Concurrent Engineering Practices Simulation

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Abstract *- Nowadays, the companies' competitive advantage is directly connected with its capacity to develop products. So, the professionals' formation, which is part of this development, needs to be one of the main concerns of the companies. This is necessary to get the benefits of the use of Concurrent Engineering techniques and its tools, and surpass the challenge of a changing global market, where product cycle is always shorter. In this context it has been developed, at a Model Integrated Factory, a Teaching Scenario. This approach emphasizes the use of active didactics techniques, which maximize the learning process, and help in the formation of people who work with product development.*

Introduction

In a global economy, the manufacturing industry's competitive advantage is directly connected with its capacity to introduce new products in the market in shorter periods of time with lower costs and high quality.

To achieve these goals many companies have adopted the Concurrent Engineering (CE) philosophy in the product development process. However, some of them have focused only on the organizational aspects of CE, just grouping people who were before in separated departments. Others have invested in integrated CAD/CAE/CAPP systems to share a unique product model.

Because of the focus in only some specific aspects, the full potential of CE is not explored. One of the main causes of this problem is that people, who work in manufacturing industries, have a partial skill. In these industries people have, basically, two kinds of backgrounds: specialist (like engineers) or manager skill. In the first one, people have a large experience in just one technical subject, but have few contacts with business knowledge, organizational aspects, financial techniques and so on. On the other hand, the managers have business know how, but few technological insights.

To minimize this problem people could learn new technologies with a business vision in enterprises or schools, but there are few places where they can learn all business dimensions at the same time.

To supply this educational need, it has been developed at FIM (Model Integrated Factory, USP São Carlos) a Teaching Scenario, where the product development business processes are simulated. This scenario has been used as a platform to teach people and to test new CE solutions. These solutions (concepts, philosophies, techniques, methods, tools and equipment) can be commercial ones or result of research, when commercial solutions don't exist.

The objective of this paper is to present that Teaching Scenario for Concurrent Engineering Practices Simulation, with main concepts and applications.

The holistic vision of business, product development characteristics, and the people skills for product development will be discussed first. Afterwards, the scenario requirements and proposal will be outlined, and finally, an application will presented.

Holistic Vision of Business

The company's holistic vision means to have in a unique representation all company's elements. This vision has different dimensions and abstraction degrees, like strategies, information, business activities, resources and organization, as well as their interrelations.

Some companies have people with this vision, and usually these companies have an outstanding position in the market. Nevertheless, the majority of managers came from specific skill areas, bringing a distorted vision of the whole. It is common to find a manager caught up with computational resources, while others are thinking that the solution is in the organizational structure, and others pay attention only to the machines and shop floor facilities, etc.

With a holistic vision, it is safer to make decisions relative to one dimension, because the consequences of this decision on the other company's dimensions are considered. If this holistic vision is formalized, we can discuss specific problems without losing understanding of the whole, and the knowledge can be equalized among the discussion participants. However, it is impossible to represent the whole in a complete form. This whole is something abstract, which joins all areas in the managers' minds.

In this way, seeing an enterprise as a collection of business processes (BPs) is the closest formalized manner to represent the holistic vision [6]

A BP consists of a group of activities that manipulate and are linked to information. These activities use the company's resources and organization. The BP forms a cohesive unit and it should be focused on a business. This business is usually focused on a specific market/client, with defined suppliers [6].

In some companies, the existence of BPs is not realized. The new client requirements, the competition increase and the more flexible information technology made the BP identification necessary. Moreover, we can manage the business in a more effective way, with focus on the client's needs [5].

The BPs should be mapped out to be reference for many other approaches, like the integrated manufacturing [1]. The whole organization should think in terms of BP [5]. The BP map is essential as a reference for discussions, with the objective to aid the systematic obtainment of a holistic vision of the company. Since the holistic vision is something abstract, there is difficulty in representing the BP [6]. The reference model is the tool used to represent the business process.

Product Development

With the growth of global competition, the customer market has been requiring an individualized treatment. To achieve this, companies must decrease the product development cycle.

An important characteristic of product development is the high degree of uncertainty in the beginning of the development, when the majority of design solutions are chosen. This uncertainty decreases along the process, but choices in the development beginning are responsible for 85% of the final product cost [4]. In addition, the cost of the alterations increases exponentially during the development process.

The objective of CE is to increase product quality (with the focus on the client), decrease the time to market, and, consequently, decrease product and development costs. To reach these objectives CE must be seen and analyzed in the context of a holistic vision of the business process that was discussed previously. In this approach, CE is defined as the philosophy used through the product development process. Many approaches, like parallelism of design and process planning activities; multifunctional team work; use of methods like QFD (Quality Function Deployment), DFMA (Design for Manufacturing and Assembly), FMEA (Failure Model and Effects Analysis) and DOE (Design of Experiments) should be understood as part of the CE philosophy.

The aspect of the BP that is considered essential for the success of CE is to improve the people skills. People and their skills are part of the organizational dimension within the holistic vision.

People Skills for Product Development

A multifunctional team should conduct the product development under the CE philosophy, so the activities may be done concurrently and the decisions made, considering the requirements and experience of all areas involved.

According to CLAUSING (1994), in the middle of the century, generalists, who kept all knowledge involved in the product, conducted the product development. This approach was possible because these products had little technology sophistication.

With the technological progress and the growth of product complexity, this approach becomes inefficient. The formation of segmented specialist was necessary, however they didn't have a complete vision of the product and only participated in some development activities.

These professional attributes brought many problems and limitations to the product development: difficulty of design with simplicity, lack of attention to the product quality, excessive development lead times, lack of integration between project and production phases, lack of focus on client, low supplier involvement in the development of products and errors in the continuous improvement process. One of the main causes of these limitations was that people contributed only as specialists, in a determinate phase of the process. This approach is a consequence of the people background.

A better approach is the formation of Product Development Teams (PDT), in which their members have a good mixture of knowledge depth and scope. This will lead to a better communication among them. When necessary, the team should use communicative specialists, who have a great technical knowledge; however, they should know the integration among their job and the other activities too. A communicative specialist has to be able to understand his colleagues work in the team collaborating with the global work. This approach avoids people to think that their job is more important rather than others (CLAUSING, 1994).

Requirements, Proposal and Concept

The traditional teaching techniques use presentations with questions and answers, and audiovisual resources. In this case the "student" behavior is almost always reactive or passive. The instructor attitude is authoritarian and it causes a gap among the students, and among these students and the instructor. This gap decreases the contact among people, making difficult the learning process.

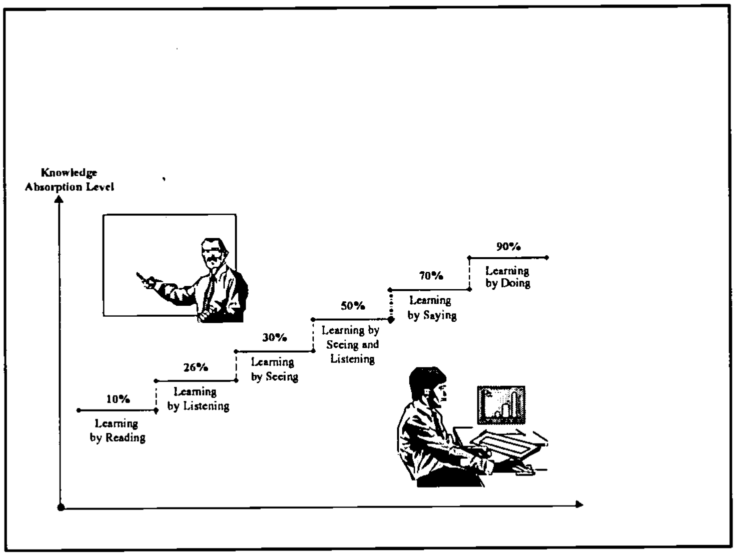

Figure 1: Education and Training Methods Efficiency [7]

In Figure 1, we can observe that this approach is located in the levels "learning by reading", "learning by listening", "learning by seeing" and "learning by seeing and listening", where the knowledge absorption is 50% at maximum.

Nowadays, new teaching techniques have been used in different areas to improve the knowledge absorption. These approaches are considered non-conventional and utilize the active didactics, with democratic relationships. With these techniques people do the process themselves and learn much more.

To supply the need for people with knowledge in CE with a holistic vision approach, it was developed at (Model Integrated Factory) FIM a new teaching proposal.

The FIM has all elements to almost become a real environment: products, people (characters created with a position and responsibilities), shop floor resources (machines, robots, etc.), offices, etc. Moreover, it is structured as a collection of BPs, like market and sell, product development, manufacturing and services. The BPs were mapped in reference models to be used as a reference for real manufacturing environments, assisting them in achieving the holistic vision,

Recently, it has been developed the "New Product Development" scenario based on a reference model for a specific type of company (an automotive supplier), with a sample product. In this development, all the knowledge (concepts, philosophies, techniques, methods, tools and systems) involved in that process were researched and systematized (Figure 2).

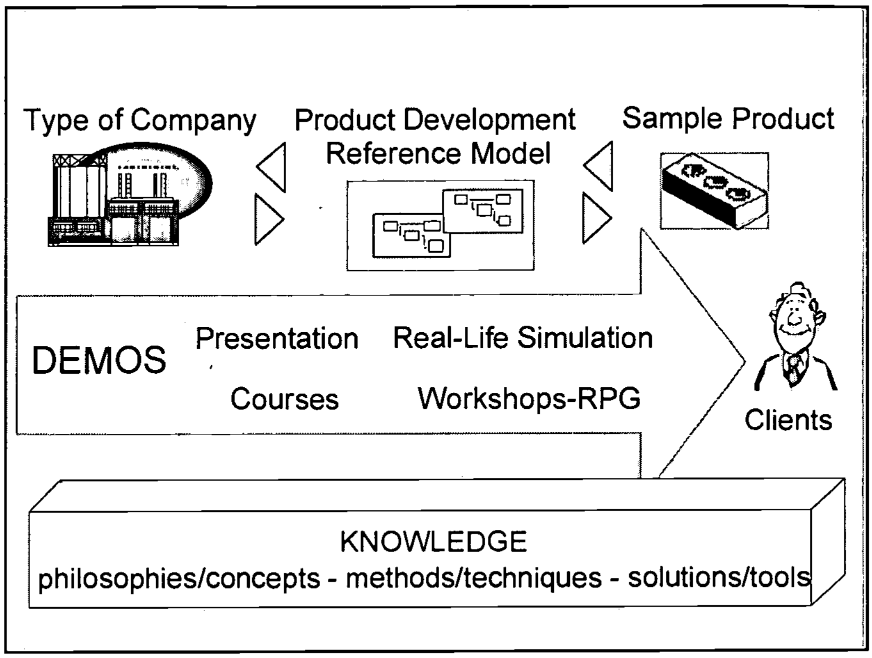

Figure 2: Elements of the Cconcurrent Engineering Scenario

This reference model contains companies' best practices concerning business process vision in agreement with QS 9000, and results from consultant projects.

The reference model involves all the steps of the product development for one kind of industry and a sample product. This model has processes from the conception of a new idea to the product validation, including concept and project.

In the Conception phase, the idea of a new product is created, with its scope and development schedule. In the next phase, Concept, the needs of the customer are taken into account, from this, the technical expectations are determined and we can now begin the following activities: drawing, process planning, make or buy decision and investment analysis.

In the Design phase, the suppliers are defined, the components' specifications (shape, dimensions, tolerances, material, etc.) and the respective process plan (tools, fixture, quality control, etc.) are detailed, the assembly is verified, and so on.

In the final phase of development, the product validation, the prototype and the pilot batch are made to validate the respective design and process. After all aforementioned activities, the company can begin the production.

In the simulation, a multifunctional team is formed to develop a new modular gearbox line. During the development phases, they apply techniques and tools, like QFD (Quality Function Deployment), DFMA (Design for Manufacturing and Assembly), FMEA (Failure Mode and Effect Analysis), CAD (Computer-Aided Design), CAPP (Computer Aided Process Planning) and PDM (Product Data Management).

The reference model is presented and discussed in depth in other articles in Portuguese [6], although new articles in English are being written to explain the model with more details.

Since one of the main objectives of this scenario is education, people can participate in several kinds of demonstrations (see Figure 2 again).

The demonstrations are made, in the form of presentations, real-life simulations, courses and workshop-RPG (role-playing games) to teach this knowledge.

In the beginning the presentation of the company, the product and the reference model are set. It is also shown the main activities:, information and knowledge involved in the product development. This presentation intends to give people a process' general vision.

A second step is the participation, in a real-life simulation, where the visitor assumes a character in the product development multifunctional team and follows a step by step script with his/her activities in the development. This real-life simulation can be passive, when the visitor follows an instructor that helps the execution of the activities and presents the knowledge involved in each activity. Another option is the active real-life simulation, where the visitor receives a previous training and then follows the script himself/herself, making the necessary decisions.

During this real-life simulation activity, the visitor takes some courses to obtain knowledge in new areas or increase his/her knowledge related to his/her profession. For example, a process planner can take a process-planning course to act a role during the simulation and then use the obtained knowledge in his job.

At the end, visitors with all necessary knowledge to take part in the product development can participate in a workshop-RPG, where they will create a script and will simulate all processes by themselves, testing many alternatives and solutions.

Application Example

As an example, part of a hypothetical situation that simulates the development of a new modular gearbox line, produced at FIM, is presented. We can divide this example in two parts: in the first part we have the "product conception" and then the "product concept", that is the most important development phase.

This small presentation is only part of the product development script. This script, composed by acts and scenes, is the base of the Product Development Simulation.

Product Conception

The first part begins with the identification of a market opportunity, when during a visit to gearbox producers, Mr. Barganha, the FIM's commercial director, knows the production of a modular gearbox line.

Mr. Barganha presents his idea, using videoconference, to the Marketing Director, Ms. Marta Marquete, to do a product attractiveness analysis. The video conference is used to start this analysis faster.

Ms. Marta Marquete analyses the information sent by Mr. Salim Barganha and arranges a meeting with the attractiveness analysis multifunctional team. In the same mail she sends information about the product and asks each one to fill out an electronic attractiveness sheet, to increase the meeting productivity.

In the meeting Ms. Marta Marquete explains Barganha's idea and consolidates the attractiveness analysis. Ms. Marquete and the analysis team observe that this new idea has a good potential to be developed. Then, after the meeting, Ms. Marquete prepares the attractiveness analysis report, which shows the new idea's results, to be presented to the administration.

In this first part are identified some concepts, techniques and tools that are taught in the simulation like: video conference, attractiveness analysis, multifunctional team, concurrent engineering, value analysis, e-mail, and other ones.

Product Concept

In this phase the main product characteristics are developed. The product specification and the development timetable, which were identified in the previous phase, are available and will be detailed. The product specification is the basic reference for the development activities. It considers several aspects, such target cost, production volume, performance, product life span, standards, company constraints and customer requirements.

Ms. Thaís Mercado and Mr. Alceu Dispor do a market analysis for a new gearbox line. After the customer interviews, the main requirements are selected and grouped. Then a report is sent to Ms. Isolda Qualli, with this information, to make the new product's QFD.

Ms. Qualli with the PDT and a key supplier begin the QFD technique application. The main requirements are high gearbox durability, low maintenance's frequency and cost, and a clean work area.

As a result of QFD analysis, they decide to improve the lubricating system, to increase the bearings' life and thus increase the gearbox durability and reduce the costs and frequency of maintenance. The problem with the oil leak, to maintain the work area clean, is solved with the decrease of the roughness in the shafts' sealing seat. Then Ms. Qualli prepares the technical requirements report with this information.

At same time Mr. Décio Dezaine specifies the gearbox lines (module, teeth number, reduction, and so on) and drafts the assembly drawing, considering the technical requirement. After that, Mr. Dezaine and Mr. Sabino Sequencia consult the product specification, analyze the information and draft the assembly drawing. Mr. Dezaine consults the part classification system to look for old assembly and part designs to be reused. He notices that some shafts and gears design can be used with small changes.

Using this recover information Mr. Sequencia structures the product using specific software developed for this purpose. After that he generates process plans to the parts that are in the structure.

Mr. Dezaine, Mr. Sequencia and Ms. Lidia Taime begin a make or buy analysis for the output shaft. With some information like machine sequence, manufacturing time and tool cost they calculate the manufacturing cost for this part. Then they analyze the cost, price, delivery time, etc. from suppliers. After this analysis they decide to manufacture the shaft.

After the make or buy analysis Ms. Lidia Taime receives the manufacturing part list and verify that there are not sufficient grinding machines to produce the shafts. Mr. Sabino Sequencia specifies the technical characteristics to the new machine. And Ms. Carla Caunt plans the purchase and verifies the investment plan for the grinding machine.

Ms. Daliga presents the concepts results to the group concept, and details the product target. These concept results are approved and the project phase begins.

The knowledge involved in this part is: QFD (Quality Function Deployment), CAPP (Computer Aided Process Planning), PDM (Product Data

Management), ABC (Activity Based Costing), BOM (Bill of Material), Concurrent Engineering and others,

This example is only a part of the simulation; the whole script is more complete. But, the purpose of this example is only to give an idea of how simulation happens.

Final Remarks

The main benefits of this teaching proposal is the possibility to experience the work using a reference model, which enables a more extensive vision of the companies business process, as well as the habit of use them.

Moreover, the importance of the use of CE philosophy and its tools, as facilitators of the multifunctional team's work, is formalized.

This teaching proposal has already been applied once with a group of mechanical engineering students from the University of São Paulo.

These students, during 40 hours, played the role of the virtual gearbox company characters. They had real-life simulations of the main activities in the product development process with their responsibilities and decisions. To do this work, they used some tools, which support the product development process.

To measure the results of this work and the students' knowledge absorption level, a questionnaire was elaborated and applied. In this questionnaire, several points like duration, didactic and available resources were checked.

More information about the results of this simulation will be presented in a future paper. Nevertheless, in an interview to a Brazilian newspaper, one student who participated in the simulation said "I was surprised with the course, because we don't have anything like this in our undergraduate course. We didn't know the existence of some concepts that we learned and we didn't know how a company worked before this course" [3]. This interview is an indicator that we are in the right direction.

References

1) BARRET, J. (1993), "Process Visualization: Getting the Vision Right", Oracle Magazine, v.7, n.1, p.69-78.
2) CLAUSING, D. P. (1994), "Total Quality Development: A step-by-step guide to world class concurrent engineering", The American Society of Mechanical Engineers.
3) COSTA, E. A. (1997), "Entra em operação a fábrica do futuro", Gazeta Mercantil, (10/31), pp. A-9.
4) EVERSHEIM, W. (1989), "Organisation in der Produktionstechnik Band 2: Konstruktion", VDI-Verlag GmbH, Düsseldorf, Germany.
5) GARVIN, D. A. (1995), "Leveraging Process for Strategic Advantage", Harvard Business Review, v.73, n.5, pp. 76-90.
6) ROZENFELD, H. (1996), "Reflexões sobre a Manufatura Integrada por Computador (CIM)", Manufatura Classe Mundial: Mitos e Realidade, São Paulo.
7) STICE, J.E. (s.d.), "Using Kolb's Learning Cycle to Improve Student Learning", Engineering Education, v.77, n.5, Feb, pp. 291-296, s/d.

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