Proposal and application of a model for analysis of knowledge management in the product development process

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Resumo: The aim of this paper is to propose a model to the analysis of the Knowledge Management in the product development processes (PDP). The tendency of growing economy globalization, the increase of products diversity and the decrease in the life cycle of these products in the market made the Product Development Process (PDP) turn into an important source of competitive advantage. To give power to this process, it's necessary to managing a important resource: the knowledge. It's in the context of the search of a more structured knowledge management in the PDP that the described model in this article is proposed. The contents, the process, the infrastructure and the Knowledge Management principles (essential elements of this model) are already present in the product development process and what guides the model for analysis here proposed is the awareness of this existence and, with this, improve the power of this management. The model is applied through a case study in the PDP of an automotive supplier company.

Key words: knowledge management; product development process; model

1. Introduction

The tendency of growing economy globalization, the increase of products diversity and the decrease in the life cycle of these products in the market made the Product Development Process (PDP) turn into an important font of competitive advantage (TOLEDO, 1994)

The performance of this process, as said by TOLEDO (1994) depends on the capacity of the companies to manage the development and perfectioning process of the products and the interaction with the market and the technological innovation sources.

Inside of the management of the Product Development Process, includes the Knowledge Management. The knowledge can be considered an essential input of this process, a key element on the transformation of this entry and an important output; therefore, the product development process is one of the processes where the necessity of Knowledge Management shows itself in its most critic form.

Inspired on this picture, the organizations start to search for a more structured way of managing this important resource, the Knowledge. This article has as an objective to propose and to apply a model to analyze the Knowledge Management in the product development process, to give power to this important source of competitive advantage. The model is an alternative way of analyzing the product development process, under the eye of the Knowledge Management.

2. The dimensions of model

For the understanding of the Knowledge Management is needed to make clear that, as in any other management approach, it is constituted of principles and practical experiences. The principles are values and beliefs that direct the actions in an organization. The practices of knowledge management are these actions and some elements like infrastructure.

It's worth to remind that these two dimensions of the Knowledge Management are essential and must co-exist in an organization: it's needed to develop and maintain the knowledge strengthening principles and also translate them into practical mechanisms. The lack of one of these can destructurate all this management, making it short-lived, because the organization would be focused only in the "philosophy" of the knowledge or in practices, without any link with its principles.

2.1. The principles

NONAKA and TAKEUCHI (apud DAVENPORT and PRUSAK, 1999) affirm that the power of knowledge is provenient of values and beliefs, and also of information and logic, confirming, like that, the importance of the reigning principles of the Knowledge Management.

The reflection on the knowledge management principles goes back to the base of the Organization Learning base, with the five disciplines proposed by SENGE (1990) for the organizations turned to learning. It is noticed, really, in these subjects a character of principles, because on them are presented the believes that the organization turned to learning must have and not the practices that it must adopt.

This way, it can be assumed, in this article, that the Knowledge Management principles are based on the five subjects of SENGE (1990), to be known.

♦ Personal Domain

♦ Common Goals

♦ Mental Models

♦ Group Learning

♦ Systemic Vision

Related to the subject Group Learning, it can be cited another principle of the Knowledge Management, the **Sharing Culture**. This principle is related to the way the members "face" the necessity to share the knowledge. With this principle is searched the exchange of the idea "who holds the knowledge, has the power" to "who exchanges the knowledge, has the power". To BEIJERSE (1999), this principle is represented by the cooperation stimulus among the members.

Apart from these subjects, two other principles are essential to Knowledge Management: the **Opening Climate** and the **Error Treatment**.

The Opening Climate principle is about the liberty and use given to the inventiveness of the organization members, being able to limit or expand the knowledge creation. The Error Treatment (LEONARD-BARTON, 1995: 15) is very much related to the knowledge creation through what is called "attempt and error". If the error is treated as something abominable, this creation form can be penalized.

2.2. The practices

According to DAVENPORT and PRUSAK (1999:204): "without a method to manage the structured knowledge, the organization learning (in this paper represented by the knowledge management principles) is far too much conceited and abstract to make any difference in a long term in the organizations". It is in this context where the importance of the

practices of the Knowledge Management is inserted.

This dimension of the Knowledge Management can be analyzed following some elements of the called "Knowledge Portfolio", proposed by BIRCHALL and TOVSTIGA (1998): content, process and infrastructure.

BIRCHALL & TOVSTIGA (1998) define the content element as a knowledge group that is strategically important to the company.

The knowledge can be classified (NONAKA & TAKEUCHI, 1995) in:

♦ Tacit Knowledge: something difficult to be formalized and communicated to others.

♦ Explicit Knowledge: formal and systemic, easy to be communicated to others.

These knowledge contents will have their dynamicity in the organization as a base in the creation and knowledge exchange processes, second element of the knowledge management practices.

BIRCHALL & TOVSTIGA (1998) give the concept of the second element of knowledge analysis as the processes by which the knowledge is administrated inside the company, that is, how it is generated, identified, stocked, disseminated, used and discarded.

BELL (apud OLIVEIRA, 1996) proposes some learning methods:

♦ Learn with past experiences

♦ Learn with others

♦ Learn with changes

♦ Learn with the performance analysis

♦ Learn by training

♦ Learn by contracting

♦ Learn by search (represented by the transfer of Technology. Information are coded in a way that they need to be understood, incorporated and registered)

This processes cited by BELL (apud OLIVEIRA, 1996) can be analyzed in the same way as the classifying mechanisms proposed by NONAKA & TAKEUCHI (1995), that has as a base, the differentiation between tacit and explicit knowledge.

♦ From tacit to tacit (Socialization)

♦ From tacit to explicit (Externalization)

♦ From explicit to explicit (Combination)

♦ From the explicit to tacit (Internalization)

These processes and also the content element are strongly influenced by the infrastructure elements.

According to BIRCHALL and TOVSTIGA (1998), the infrastructure incorporates all the functional elements of the company that support and ease the administration of the knowledge. In this article, the infrastructure element is focused in the organizational structure, in the human resources policies and in the Information Technology management.

In terms of organizational structure, is ideal to stress the importance given to the teams in a Knowledge Management structure. "The real context in which occurs the greatest part of the conversion of knowledge is in the team level" (NONAKA & TAKEUCHI, 1995).

According to ERNST & YOUNG´S research (1998), the team organizational structure is utilized extensively in the product development process, for reducing the effort redundancy and by being a natural source of knowledge exchange. Meanwhile, only the team formation, as an elimination of the special separations isn't enough to the effective exchange of knowledge (CALABRESE, 1999). It is necessary, also, delegation to those teams, a bureaucracy reduction, the adoption of a common language and a definition of clear and concise objectives.

In terms of human resources management, FLEURY & FLEURY (2000) three points are highlighted, which turn into being Knowledge Management potentializers.

♦ Caption: in the recruitment and selection processes, new processes and techniques must be employed, aiming to identify people with growth potential, flexibility and with values coherent to the Knowledge Management principles.

♦ Development: all person's development processes must be aligned to a definition of business strategies and essential competence of the organization.

♦ Remuneration: in this item, it is observed the adoption of new remuneration forms, as a participation on the results, a variable remuneration, a remuneration based on the competence and on group work.

All the personnel policies, inside the knowledge management context, must try to reinforce the guiding principles of this management. It is through these policies that an organization renews and strengthens these basic values to the knowledge management.

The Information Technology utilized in the knowledge management is the one that not only captures and distributes the structured knowledge, but also makes viable the tacit knowledge transfer among the persons, as the videoconference and the telephone. (DAVENPORT and PRUSAK, 1999).

DAVENPORT and PRUSAK (1999) discuss some infrastructure technologies that make possible the knowledge transfer, like the **explicit structured knowledge reposition** and the **specialists systems**.

The technologic tools that support the creation and the understanding are more important in the product development process than the technologies that only support the communication (ERNEST & YOUNG research, 1998). Technologies that allow hypotheses tests about the real world, that permit the organization of a great group of data and forecast about the future, help the people to use the knowledge and not only share it.

To finalize the discussion about the knowledge management infrastructure, it is important to stress that isolated technology doesn't change a company into knowledge creator (DAVENPORT and PRUSAK, 1999). The technology is common in the knowledge distribution field, but rarely promotes the process of knowledge use. Also, the technology information turns into something of relatively less use in what refers to knowledge creation, which is in great measure still an individual or group act.

After analyzing the knowledge management elements to the proposed model, the article describes the case study, where this model was utilized as an analysis base.

3. Case study analysis

3.1. Characteristics of the product development process in the shock absorber supplier

The case study was made in a shock absorber supplier company, localized in Santo André, Sao Paulo state. The company has in its board about 2.500 employees.

For the company, the product development process starts with the so-called development intention, where the clients

give some directions about the new product. From this intention, an initial quotation is needed to be made (with a forecast of costs and investments), because the assembly companies usually choose between two or more suppliers. To the presentation of this quotation, technical and financial analyses of factorability are made; in case of a negative result of any of these analyses, the company retracts itself from the quotation. If the company's quotation is chose, the client elaborates an intention letter, which gives start to the necessary investments.

After this, internal (inside the own company) and external (inside the assembly company) work groups are formed. According to the interviewed people, these groups should be made since the moment of the development intention, because this initial moment is extremely important to the entire process, but in practice, they can't form them, due to the uncertainty of the project realization.

In the group development phase is where the product and process engineering activities and the tests are; the majority of the product development activities are concentrated in this phase. With this phase finished, the product needs to be certified and homologated and then, it is sent to the manufacturing area and stays under the quality area responsibility.

In the description of these steps, a bigger amplitude is noted if compared to the steps proposed by CLARK & FUJIMOTO (1991), because for the company, this process involves the "negotiation' with the companies and the following of the project's result. This fact is positive to the company, because it permits the visualization of the global process, from the development intention, and not only in the engineering activity focuses, which are present in one of the steps, which is the group development.

In terms of organizational structure, the product development process is organized in a matrix form. In each project, multi-functional groups are formed, but even though they develop the activities of their functional area, that is, they are not exclusively dedicated to the project. The interviewed stressed that the total dedication to the project would be ideal, but impossible to be implanted in the company's practice.

All this characterization of the product development process will be important to give context to analysis in the knowledge management, which begins in the next item.

3.2. Knowledge management

The product development analysis of the shock absorber supplier under the knowledge management optic will be structured with basis in the element before described. The principles and infrastructure elements were analyzed in a general form for the PDP, but in content and processes terms, the article will be focused in two types of knowledge: the Factory Voice knowledge (knowledge to be transformed) and the knowledge about the DFMA (Design for Manufacturing and Assembly) tool, which is a transforming knowledge.

In the process of buying by which the company is going through, are being made constant "hearings" by the interested group. The engineering area has been charged, mainly, in terms of knowledge management practices by the group interested in buying it. The analysis of this case can be, then, be utile to diagnostic the process development process situation in terms of knowledge management and also signalize some possible efforts to improve this situation.

3.2.1. Principles and infrastructure

In terms of the **Personal Domain** principle, it is noted that there is a gap in the product development process of the company. The analysis of the performance is made only at the end of each project, because according to the interviewed, the indicators only are shown in this moment. The company is very focused in final indicators of time, price, quality and profit, which were dealt with the clients and shareholders, and forgets that to reach them partial indicators are needed, which should be monitored during all the process. With this situation, the members of the product development don't have the exact conscience of the state they are in relation to the project's objectives and so, can stop evolving. Apart from that, the performance analysis only in the end of the project discards the possibilities of learning with the experience, which could bring effects in the process in continuation.

The **Common Objective** principle is very strengthened in the analyzed development process; the final objectives are dealt with the clients and shareholders and after, the partial objectives are established in conjunction with the work group. There is a search, according to the interviewed, so that these objectives are factorable, but also challenging.

The two principles analyzed before are very related to one another, the first gives conscience in the actual situation terms and the second, in the aimed situation terms.

The company affirms it is aware and constantly searches for the identification of the **Mental Models** of the PDP participants, in way to increase the potential and disseminate positive ideas and minimize the negative ideas. The mental model that is searched to disseminate is the one where the actual situation is very different of the situation present some years ago; the company is not the "sovereign" in the market, with no competition, and could offer the product that it wanted, in the price that was convenient to it. With this work, the company can be much more open today, than before the beginning of the dissemination process of this mental model (through talks and systematic training). Another present mental model, related to this first is that the company must be open to changes, but always with questioning and criteria.

A noticed mental model that can be negative in relation to the knowledge management is the vision that other areas have on the Engineering area; it is seen as an isolated area, which is felt to be independent and sovereign (this model is also shared by the Engineering personnel). This vision was noticed by the company that has searched to change it, strengthening the **Systemic Vision**. With this principle strengthened, the PDP members will notice that all the areas have a relevant role in the development process and that its activities are inter-related and are inter-dependant. The attempt to join the product and process engineering had the objective to strengthen the systemic vision (to project the product already thought in the process effects), but as this joining has became not viable, the challenge is even greater in terms of this principle. The organization has stimulated that the process development process members think always in the extern client, but also in the internal client.

The analyzed company noticed through a knowledge management principle, the error in other principle. Through a mental model noticed by the company (the negative vision over the engineering area), it could understand that the systemic vision needed to be stimulated in the product development process.

The **Group Learning** principle is favored by the PDP organizational structure, which is in team, and also by the objectives establishing for the group and not for the individual. In another way, this learning can be dismotivated by the **remuneration system** in the product development process: the members have their individual wages, as the position they have and can receive bonuses, periodically, as their deserving. These bonuses by deserving are distributed by the functional area manager to which the member belongs, and not by the leader of the product development group. So, there is a misbalance: the members are organized to work in groups and receive common objectives, but have their remuneration with a totally individual basis.

This totally individual remuneration system can also be one of the responsible for the weakening of the **Sharing Culture** principle. Although the knowledge exchange is the basis for the success of the product development process, as the interviewers affirm, many times, this exchange doesn't occur. It was stressed that some members "hold" their knowledge until the moment they judge best (and when, usually, it isn't the best moment for the group) so that they are recognized after. For these members, the idea that still prevails is the following: "those who hold the knowledge, have the power". Maybe a group reward, not only an individual, will not be the only solution for this problem, because there are personal values involved in this matter, but it could stimulate the knowledge exchange a bit more. A way used by the company to minimalize this problem is through the own group knowledge (that know that the member knows and that that is the best moment for the exchange), which pressures the member so that he exchanges the necessary knowledge in that moment.

The **Opening Climate** was already cited when the mental models were analyzed. The company has searched for an increasing opening to ideas, but always with criteria. One of the company's practice that can express this principle is the systemic use of the "benchmarking". The company has as a politic the constant analysis of the competition and their products; this "gross" analysis circulates among the departments so that they can create something more on what they have and, according to the interviewed, is in this moment that the members show their creativity. Each suggestion is, then, analyzed with great criteria so that the members don't feel unmotivated to suggest other times.

The last principle to be analyzed, in this case, is the **Error Treatment.** In the company's PDP, there is liberty to experiment and consequently, to try and fail. It is clear that the continuous error isn't well seen, and so, when an error happens, it searches to analyze its causes in-group and so learn with them. It was noticed, also, that this principle has different powers according to the process step; according to

the interviewed, it is preferable that the error happens in the anterior steps, so then it is possible to take corrective actions, in way that it doesn't affect the client's perception.

In relation to the knowledge management infrastructure, the analysis starts by the human resources policies. It was already highlighted the negative effect of the remuneration system of the PDP, for being individualists and functional. In terms of **selection** of PDP members, the requisite are the technical abilities (knowledge in areas that are necessary to the product development) and also behaviorists, as the easiness to work in-group, communication, among others. These requisites are positive to the knowledge management, because the members will have the necessary technical knowledge and will be open to the knowledge exchange; what happens, instead, is that not always these behavior requisites are fulfilled and the members oppose themselves to the knowledge exchange, as it was shown before. This problem can be caused by the difficulty in evaluate, in a selection process, these behavior requisites, by their highly subjective nature.

The company assumes that it has prioritized the internal **professional development** of the PDP members. This politic demands that the employee have only the basic formation, and permits that he receives, in the own company, the specific knowledge necessary to his work. This politic favors the knowledge management, because it incentives the internal search for knowledge and also in terms of content, because the employee is trained with the specific ability for the company. Although, in some cases, where the ability necessary is very specific and difficult to be trained, the company has opted by employing people that already bring this knowledge from outside (from universities or other companies); this is because of the difficulty and the costs of training him and after keep him in the company.

The other element of the knowledge management infrastructure to be analyzed is the **information technology** used in the PDP. The company uses the Internet as a means of communication among its members (recently, all its members have an electronic address) and it has well-organized database, with details of former products development. Despite, the company doesn't have a groupware system, or specialized systems or knowledge base, which could support the knowledge creation and understanding. The current database could be better used if tools that permit the knowledge generation from this database existed, and also make easier

the individual know-how externalization available to everyone through a knowledge base. According to the interviewed, the company has a very good record on product information, but not on the knowledge acquired in the product development process.

It is needed to state that only the implantation of a technology to store and disseminate the knowledge about the process wouldn't be enough to stimulate the knowledge exchange; it would be necessary other politics (as a new remuneration system) to stimulate the members to share their knowledge and also access the stored knowledge.

With this analysis, the principles and infrastructure ends and we start to analyze the contents focused in this paper and the exchange processes to them related.

3.2.2. The factory voice knowledge

In the product development process of the analyzed company, the following knowledge related to the factory voice are used:

♦ Knowledge about the manufacturing process steps

♦ Knowledge about the production capacity

♦ Knowledge about the equipment available in the manufacture

♦ Knowledge about the working capacity in the manufacture

♦ Knowledge about the material available in the manufacture

♦ Knowledge about the easiest process able materials

♦ Knowledge about the suppliers' production process (that produce parts to the company)

So that this knowledge comes up in the PDP there are pre-established, which demand for a search on these knowledge; as a result from these activities documents must be generated to formalize this knowledge. As an example, there is the activity that will access the knowledge about the production process steps, which resulting document must be the process flux diagram

This knowledge is treated in this company as knowledge to be transformed and so, it can suffer changes during the PDP; they are not seen as something fixed and rigid. Even the knowledge about the production process of their sub-

suppliers can be changed, because the members of the buying area know the sub-suppliers processes and can make improvement suggestions.

The Factory Voice knowledge is present since the first steps of the product development process and reaches the PDP in different ways. In the product factorability analysis, the factory voice knowledge reaches the PDP through the production manager. The manager's participation is limited to this step of the process, because of the scarcity of time for a greater participation.

In the first development activities, a factory member should bring the factory voice knowledge through his participation in the work groups, but in reality, this doesn't happen, because the factory members only participate effectively in the developing process and in the pilot production phases. To suppress this absence, the process-engineering members, who have some knowledge about the factory, (it was them who projected the process) bring the factory voice knowledge to the PDP. When this knowledge is not enough, the PDP members go to the factory to fetch the necessary knowledge, many times, with the own operators that have specialized knowledge.

The fact of the use of the knowledge on the Factory Voice through the process engineering can bring some problems to the PDP. This is because not always that process that was projected is totally implemented in the manufacture; the factory personnel makes changes in the process and don't update the knowledge of the process engineering (some times, by being afraid of being punished by changing), and with this, the error spreads, because the engineering is going to use that obsolete knowledge in another project. The problem is only solved when the factory member starts to directly participate in the development group, but as this only occurs in the final steps of the process, the modifications can bring greater costs and delays.

This problem could be cured with some measures:

♦ .Effective participation of the production members since the PDP first activities

♦ Greater stimulus to the actualization of the Factory Voice Knowledge, since this knowledge is knowledge to be transformed (the organization must show that it is open to changes, since they are communicated);

♦ Greater stimulus to the search of the "in loco" Factory Voice knowledge; through more frequent visits of the PDP members to the factory.

In the steps of the process development and pilot production, the factory voice knowledge is present through the own production area member. This member isn't the manager, because of the lack of time already cited, nor an operator, which has the knowledge very specialized; usually this member is a cell chief (the factory is divided into as many cells as the product parts), that has a much ample knowledge on the process he is responsible.

Despite the already cited problems, the company manages to establish a certain balance, in terms of Factory Voice knowledge. This balance is obtained because the company works with this knowledge in its tacit state, through the participant members of the PDP, but also in the explicit state, through documents generated and meeting minutes, that go through one step to the other, without demanding the members physical presence. The figure 1 tries to represent how the management of the Factory Voice knowledge is done, in the PDP of this shock absorber supplier.

In the next item, the management of the DFMA tool knowledge will be analyzed.

3.2.3. The DFMA tool knowledge

In the product development process analyzed, the knowledge about the DFMA tool is present in the three possible states: in the concept level (the members have a concept that is needed to project thinking about the fabrication and assembly methods), in the form levels that ease the implementation of the tool and also in software.

It was noticed, although, that as according to the state in which this knowledge is found, the number of people that have it varies. In the concept level, the knowledge is disseminated by a great part of the development group; but in the forms and software level it is restricted to a group specialized in this tool.

This group of specialists is a kind of "internal consultants", who are searched by the development group when necessary. The fact that they don't participate in the development group can bring some problems; these specialists have the knowledge about concepts and rules generic to the DFMA tool, but don't have the deep knowledge

about the specific project in way, and these two knowledge need to be totally integrated so that the use of the tool can be powered up.

The specialist group is trained by companies specialized in the DFMA tool, but the analyzed company also uses to employ people that already have this knowledge. This strategy of bringing the knowledge from outside (assimilation) is coherent to this kind of knowledge, because it is a transforming knowledge and not knowledge to be transformed. Apart from this, the company adopts the politic of multiplicators: the employees trained by the external company train other employees, disseminating this knowledge, even being restricted to the specialists group.

According to the interviewed, the knowledge about the DFMA tool is more used in the beginning of the project (in the first third of the project), because in the remaindering time, the project has to be "frozen", in other words, it cannot suffer great alterations.

4. Conclusions

As DAVENPORT and PRUSAK affirm (1999), the knowledge isn't something new; it was always used and exchanged in the organizations. According to these authors, "new is to recognize the knowledge as a corporative resource and understand the necessity to administrate it and surround it with the same care dedicated to the obtainment of other more tangible resources values" (DAVENPORT and PRUSAK (1999): 14).

It is in the search for a more structured knowledge management contexts that the model described in this article was proposed. The content, the processes, the infrastructure and the Knowledge Management principles are already present in the product development process and what objectives the model for analysis here proposed is the awareness of this existence and the powering of this management, with the possibilities offered.

It can be concluded by this case that the company presents a balance between the principles and the practices of the knowledge management, in the product development process.

The shock absorber supplier has some principles strengthened, as the Common Objective, the Mental Models, the Opening Climate and the Error Treatment principles. In infrastructure terms, the company needs to re-structure its remunerating system and also make more intense use of the Information Technology, to power the knowledge management.

In relation to the knowledge contents focused, it is noticed that a greater use of the knowledge to be transformed (Factory Voice knowledge) is used instead of the transforming knowledge (knowledge on the DFMA tool).

In the knowledge on the DFMA tool case, the exchange processes are very limited to combination (exchange that is strict to the explicit state), because this knowledge is sent through training to the group specialized in this tool and after, used by this group in the PDP, through forms and software. What is left from this tool in the tacit state, is the knowledge on the tool in the concept level; although, about this knowledge level, it wasn't noticed any exchange process structured by the company. An alternative for this knowledge to be internalized, would be the use of the tool by the very PDP members ("learn doing"), that could, still, integrate the knowledge on the DFMA tool and the Factory Voice, bringing better results.

In the other hand, the company can achieve a greater balance in the processes of the Factory Voice knowledge exchange. The company's PDP uses this knowledge through the externalization and combination, when documents and meeting minutes are generated and exchanged, and also through internalization and socialization, when the PDP members are together with some factory member or are in the own factory.

Figure 2 tries to summarize the global analysis on the knowledge management in the product development process of the automotive supplier.

It is important to stress that all the knowledge management elements are strengthened in the company's PDP, they are not kept in a conscientious way; the company doesn't take actions with the objective of maximizing the knowledge management, and yes, with the purpose of keeping the routine activities. This way, this analysis can be useful to this awareness, as also to serve as a starting point to drive efforts to the weak or absent elements.

As the model is only an abstraction of the reality, the limitations are present. In each organization, with its specificities, can appear other factors that influence the knowledge management. In any way, it is hoped that this model

comes to help the organizations, in the sense of a first direction in the product development process knowledge management.

In this way, this model will be "lapidated" with other practical applications, which are future plans from this article's authors.

5. Acknowledgements

6. References

1. BEIJERSE, R.P. Questions in knowledge management: defining and conceptualising a phenomenon. **Journal of Knowledge Management**. MCB. Vol. 3. Issue 2. 1999.

2. BIRCHALL, D. W.; TOVSTIGA, G. **Methodology for assessing the strategic impact of a firm's knowledge portfolio.** Anais do 8º International Forum on Technology Management. França. 1998.

3. CALABRESE, G. Managing information in product development. **Logistics Information Management**, Vol. 12 Issue 6. 1999.

4. CLARK, K. B. ; FUJIMOTO, T. **Product Development Performance: strategy, organization and management in the world auto industry**. Boston, HBS Press, 1991.

5. DAVENPORT, T. H.; PRUSAK, L. **Conhecimento Empresarial**. São Paulo: Publifolha, 1999.

6. ERNST&YOUNG. **Survey - Managing knowledge during new product development**.
site www.businessinnovation.ey.com . 1998.

7. FLEURY, A.; FLEURY, M.T.L. **Estratégias empresariais e formação de competências: um quebra-cabeça caleidoscópico da indústria brasileira**. São Paulo, Atlas, 1995. 167p.

8. HEDLUND, G. A model of knowledge management and N-form corporation. **Strategic Mangement Journal**. Vol. 15. 1994. p.73-90.

9. NONAKA, I. The Knowledge-Creating Company. **Harvard Business Review**. Novembro-Dezembro. 1991. p.96-104.

10. OLIVEIRA, M. M. J. Aprendizagem Organizacional: Vatagem Competitiva em Ambientes Turbulentos. **Economia & Empresa**, São Paulo, v. 3, n. 4. 1996. p. 4-19

11. SENGE, P. M. **A Quinta Disciplina**. Editora Best Seller. 1990.

12. TOLEDO, J.C. Gestão da Mudança da Qualidade de Produto. **Revista Gestão & Produção**, DEP/UFSCar, v.1, n.2, 1994, p.104-124.

13. TOLEDO, J. C. et al.. **Modelo de Referência para Gestão do Processo de Desenvolvimento de Produto: Aplicações na Indústria de Autopeças.** Relatório de Pesquisa, FAPESP, DEP/UFSCar, 2000.

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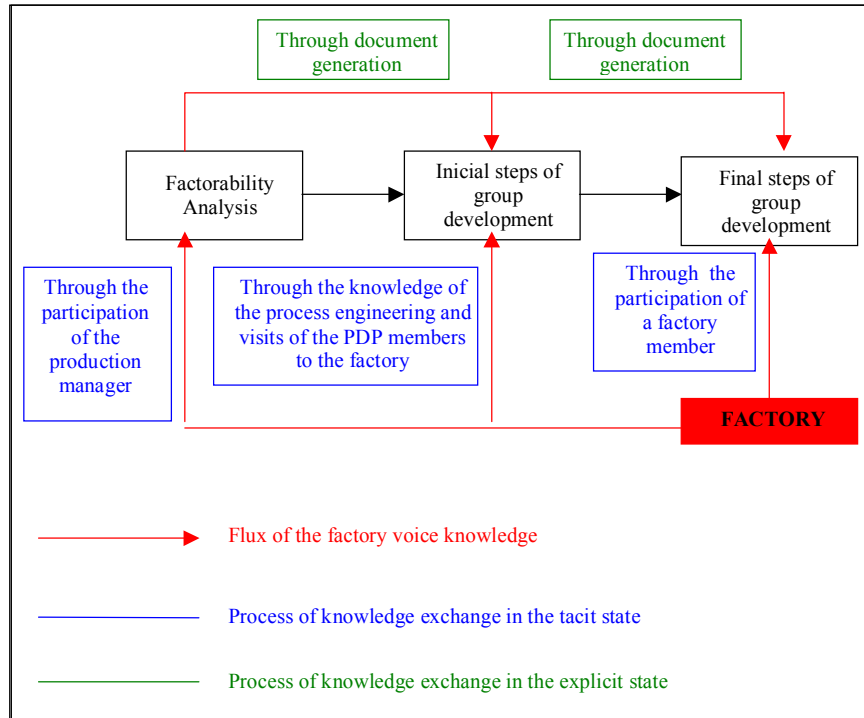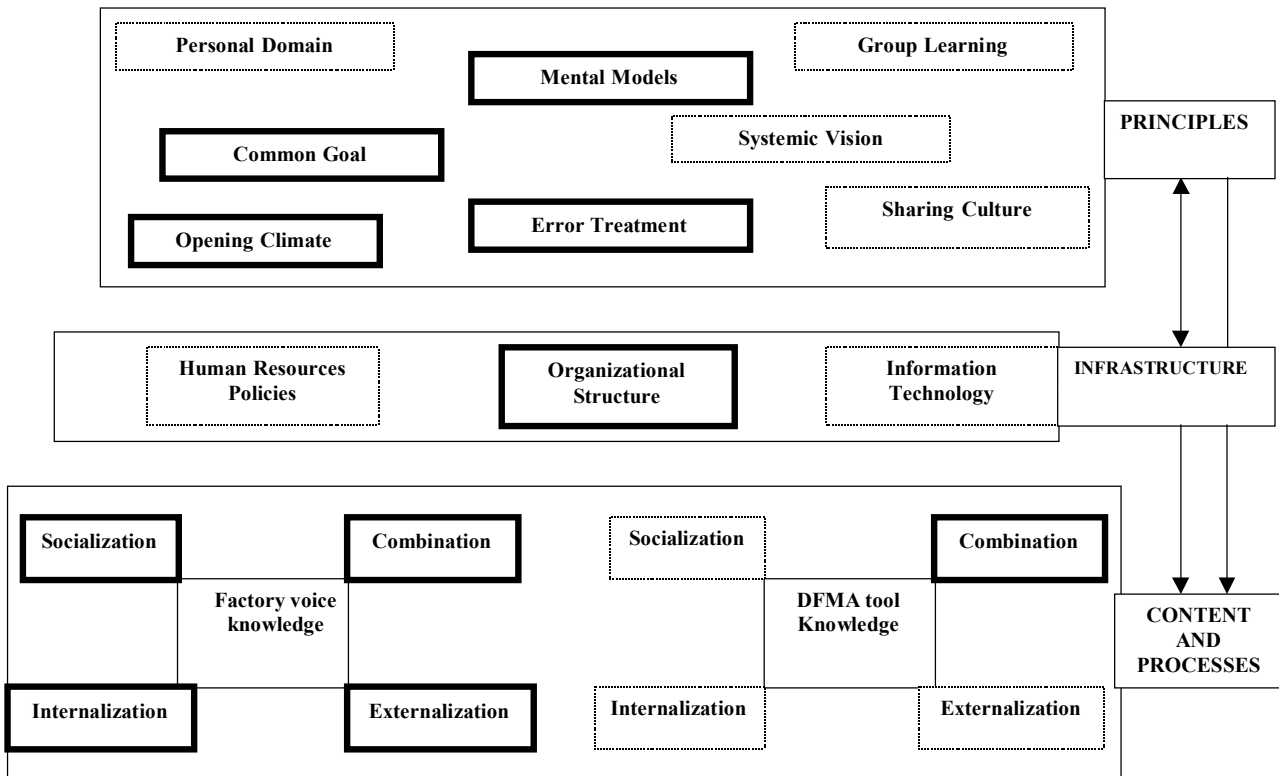Figure 1 – Factory Voice Knowledge Management in the PDP

Figure 2 – Model application to analysis knowlege management in the PDP

Strong elements in this PDP

Weakened elements in this PDP