PROJECT BEST PRACTICES: GUIDELINES FOR THE PRODUCTS DEVELOPMENT IN INDUSTRIAL SME'S

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Abstract. *The qualification to innovate has become an activity that, by the large content of specialized knowledge, demands actions, investments, abilities, experiences, teams and inter-relations especially toward the generation and the management of the technological change. Thus, the technological learning processes are, without a doubt, decisive for the constitution of these qualifications and competences. The approach of an interactive model of innovation, in parallel with the competition new rules advent, that is, with the need to reduction launching time to market of new products and the capacity to modify and to adapt it by the identification of the consumer's choices, demand in the industrial small and medium enterprises (SME's), a strategy of technological innovation. In this article will be argued a support model to the SME's, through a technological innovation factors diagnosis. This mapping, configured in a guidelines set, will guide the effort of technological innovation, in this enterprises category of the metal-mechanical sector, in selecting and managing the pertinent tools and technologies to the new products development, in accordance with its specific activities and contingencies.*

Keywords: *Design Methodology; Innovation; Product Development; Small and Medium Enterprises (SME's).*

1. INTRODUCTION

Traditionally, the main difficulties faced from small and medium enterprises related to the strategic management of technological innovation involve their lack of administrative abilities, the insufficient attention generally dedicated to the technology as a strategic variable, the reduced reach and instability of their fields or niches of performance, and the lack of qualified competitors.

Consequently, there is a clear necessity of formulating strategies capable of combining technologies with market opportunities, with the intention to reach a dynamic correspondence between an innovative attitude and requirements of the market. It is only by means of such dynamic strategies that the objective of an effective and lasting competitiveness can be reached through the innovation. The generated innovations will enable the company to improve substantially their competitive position by means of a larger correspondence among the market demands for a certain characteristic or product and the ability of the company in offering it.

2. PROJECT BEST PRACTICES: A FUNDAMENTAL ROLE IN THE ORGANIZATIONS

Some simple procedures, denominated by Eder (1998) of "*industry best practices*", and used in the project process development, can have their results described in a systematic methodology. Such procedures, however, must be justified and be stored in the documentation of the project process development, because projects that work have certain characteristics that must be considered and be applied in their elaboration for being essential to guarantee the quality of the action unchained under their orientation.

When the project professionals execute the proven technologies and approaches, there is an increase in the probability of better results, for example, the improvement in the deliveries of the project, better performance and increase of the customers satisfaction. So, the project professionals improve their own performance following the best practices of projecting (Dinsmore, 2006).

The author comments that the technologies and approaches that work in real life are considered the best ones to be used. In the context of products development, however, this relation is not so clear. Many activities in the products development process cannot be followed visually, trying a tacit learning. The consequence of this is to capture which the best technologies and approaches that are being used gets difficult, turning many of the best practices as just good to apply in specific situations. That is, what it can be a good practice in small projects, it can be not completely applicable for a mega-project and vice-versa.

Thus, the project best practices are not a set of fixed rules; they are in fact a collection of technologies and approaches generally perceived as beneficial inside of the company context.

The perception of the four sets of technological innovation factors presented, as guidelines for the products development of small and medium enterprises (SME' s), follow this situational philosophy - the model fits a list of its own best practices.

When taking as guidelines, these characteristics are part of a set of indispensable criteria to be observed in the projects elaboration. Without them, these characteristics do not serve their purpose to direct, to organize and to mobilize the energy, the action and resources to promote results (Lück, 2003).

3. THE MODELS OF TECHNOLOGICAL INNOVATION

The ability to innovate has become an activity that, because of the the need of specialized knowledge, demand action, investments, special abilities, experiences, teams and interrelations directed especially toward the generation and the management of the technological change. Plonski and Muniz (2000) say that the processes of technological and organizacional learning are, without a doubt, decisive for the constitution of these qualifications and abilities**.**

3.1. The linear model of innovation

This model represents the innovation process starting with the creation of new ideas and theories whose knowledge elapses from the scientific research of basic character (Campos, 2006). The linear model of innovation was used for the representations of the innovation processes until the decade of 1980 and this model conceives the innovations as a result from successive progressions of the scientific discoveries (Plonski and Muniz, 2000).

As far as these discoveries are related to the basic research (carried through in general in the universities) they would base the applied knowledge and the technological development, they would be transferred to the economy following the sequence presented in Fig. 1.

Figure 1 - Linear sequence of knowledge transference

The linear model, in its interpretation, allows a better and easy understanding of the innovative process, however in this model there is no return of information in the interior of each one of these mentioned periods as well as there is none in among them. The information starts on the basic research and riches the commercial stage without having the return of information from the commercial stage to the research stage. Plonski and Muniz (2000) say that “the incremental innovations that characterize the technological change, that are small but important, were not being represented” in the linear model.

3.2. The interactive model of innovation

The interactive model of innovation sees the innovation technological as an activity of cumulative and incremental learning, that involves the systematization of what already was carried through, inside or outside the company.

Plonski and Muniz (2000) say that this learning is the base for the accumulation of abilities in the companies and whose main characteristics are the following:

a. It is local, being sufficiently affected for the cognitive organization and the current firm abilities;
b. It is cumulative, therefore the repetition and the experimentation improve the capacity of the ones that are involved in the process;
c. It implies more in organizational abilities than individual abilities.

The interactive conception of the innovation process appeared from a Kline and Rosenberg’s (Plonski and Muniz, 2000; Campos, 2006) work. These authors had considered that there is a circular process in the conception of innovation. This process modifies the understanding of the activities of innovation, especially when related to the competitiveness conditions. The isolated act of the invention, of the discovery, focus of the linear process, was extended and starts to enclose the whole process of diffusion, imitation, improving and commercialization of that initial discovery.

According to the authors, if the innovation is seen with the predominance of this incremental character, the company which is faster in self-development will be the pioneer, even if its contribution for science and technology has been reduced. In this case, the innovation process is directed by the activities of the companies. Figure 2 presents the interactive model of the innovation process.

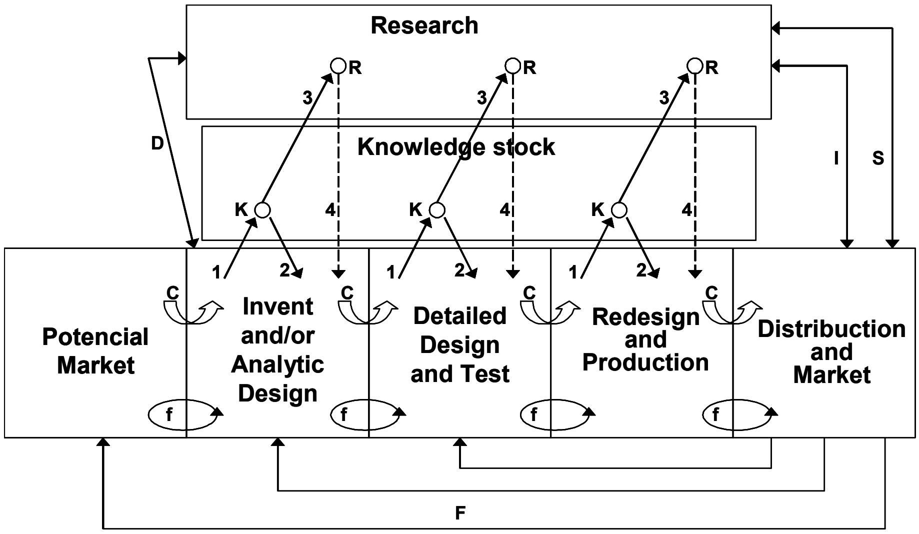

Figure 2 - Interactive model of the innovation process (Source: adapted from Plonski and Muniz, 2000; Campos, 2006).

Legend:
C – central chain of innovation.
f – feedback loops.
F – long feedback.
K – R – linking between available knowledge and research.
D – direct linking between the research and problems resulted from the invent it and the project.
I – technological tools that give support to the research.
S – the scientific research that give support to the investigated products.

This model not only establishes its own dynamics through internal relations and interactions for the company, deriving of areas as distribution or marketing, but also between companies and suppliers, customers or other organizations as university and research institutes (Plonski and Muniz, 2000).

4. GUIDELINES FOR THE PRODUCTS DEVELOPMENT: AN INTERACTIVE MODEL APPROACHING THE PROJECT BEST PRACTICES.

The boarding of an interactive model of innovation, in parallel with the advent of new norms of competition, that is, with the necessity of reduction of the time of launching the product in the market and the capacity to modify it and to adapt it from the identification of the costumers choices, demand in small and medium industrial enterprises, a strategy of technological innovation.

It's the main manager's responsibility, in the industrial SME's, using this model, to analyze which project practices are applicable in the context and the culture of the company. After getting a consensus about the respective improvements (chosen project practices), these must be incorporated in a plan, allowing SME' s to use this value added during the phases of the product development, in such a way that the company can implement its own strategies and reach its own objectives.

The proposal of formularization of a set of guidelines of the innovative effort, aims at to allow to improve the effectiveness of the process of products development, and to increase the capacity of technological innovation, in industrial small and medium enterprises located in Sao Paulo.

These guidelines will be dedicated to the process of development and management of new products, and systemize the ones to be used in small and medium industrial organizations, where the resources for development, many times, are scarce and must be well used.

Figure. 3 show, schematically, the model considered for the application of the guidelines of products development in an environment with innovative effort.

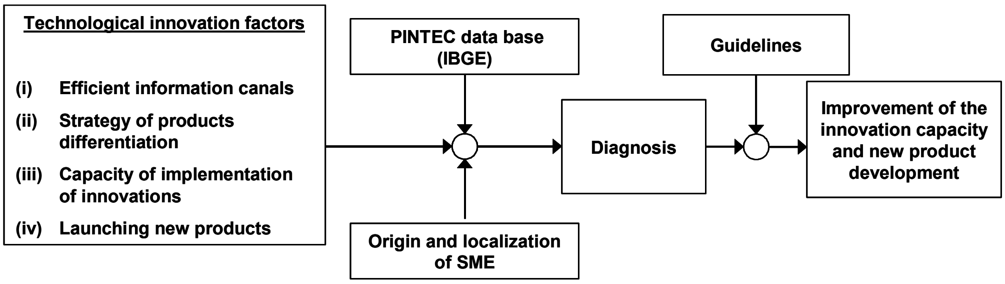

Figure 3 - Model considered for the application of the guidelines.

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4.1. The technological innovation factors

According to Oliveira and Kaminski (2006) the technological innovation can appear as consequence of different types of activities, even the most complex, like the accomplishment of research, or just simple procedures. These technological activities cannot be considered a direct reason of the innovation, that is, they are not a measurement of results, but they indicate procedures adopted by the companies guided for their occurrence.

These characteristics, according to the authors, can be evidenced from aspects that contemplate the main benefits and prescriptions of literature. The most important aspects, that are technological innovation factors, are detached in the following topics:

a. Efficient information canals: This fundamental importance characteristic that influences the capacity of learning of the companies, through the transference of knowledge between many collaborating agents.
b. Strategy of products differentiation: It is the strategy that makes possible the company to create and to offer something unique in the scope of the industrial market.
c. Capacity of implementation of innovations: Directly it is associated with the technological and industrial capacity of the companies.
d. Launching new products: It makes possible the introduction of the technological innovations in the market and understands the capacity of finding out the market needs and commercializing new products.

4.2. Diagnosis of the innovation effort.

The starting point for a diagnosis of the innovation effort will be to categorize the company about the four sets of technological innovation factors. This will be useful, because it is able to catch important aspects of the process of technological innovation in small and medium industrial companies, as for example, the effort carried through by the company in getting the contribution of customers and suppliers, use of specific tools and software, training of their employees, prospecting of the market needs, among others, where the efforts are related with the introduction of the innovation (Oliveira and Kaminki, 2006).

The considered diagnosis was extracted from the research “Products development and technological innovation in small and medium enterprises located in Sao Paulo state” (Kaminski and Oliveira, 2004) and reflects partial aspects of the innovation process, therefore it has specifically focus in the area of products development of each company, with weighed questions on the basis of the products innovation data in Sao Paulo industries in the Industrial Research of Technological Innovation - PINTEC 2003 (IBGE, 2004). It is important to remember that the cited diagnosis, uses given data referring to Sao Paulo industries and, therefore only can be applied to them.

4.3. Guidelines related to the technological innovation factors

After the diagnosis, the main guidelines are presented, and the listing of these guidelines, of didactic nature, does not aim at to establish an agreement of hierarchy of importance between them, that is, of supremacy of some over others, as far as all of them are equally important, ones in relation to the existence of the others, and for the final results of the project. These guidelines are presented on the Tab. 1, 2, 3, and 4.

These tables are formed by the requirements that must be conquered by the company, translated into questions of the questionnaire of the research on products development and technological innovation in industrial SME' s (Kaminski and Oliveira, 2004).

As far as the answers for the questions are just yes or not, the individual contribution of each question for the categorizing of the companies will be weighed for the attribution of weights, using as a parameter PINTEC 2003. The questions had been related by similarity, to the questions answered in PINTEC 2003, for companies who had implemented innovations, and its balance was applied in the answers with high degree of importance.

Table 1 – Guidelines related to the Efficient Channels of Information

G1	Do suppliers participate in the development process?
G2	Do clients participate in the development process?
G3	Are consultants hired to aid product development?
G4	Are there any works being made with universities/research institutes?
G7	Are the required tests done internally?
H9	Are the PD department employees participating of international mechanical fairs?

Table 2 – Guidelines related to the Strategies of Products Differentiation

E5	Is any national or international product development standard folowed?
E6	Is an internal development methodology followed?
G5	Are external companies hired to do the development or any part of it?
H1	Is there any formal organization chart of the company that includes the PD department?
H3	Is there any training policy for the employees?
H6	Is there any policy to be followed in terms of security of information?

Table 3 – Guidelines related to the Capacity of Implementation of Innovations

D9	Are new manufacturing processes being use?
E7	Is there any standardized procedure for the filling of drawings, calculus memorials, test results, etc.?
E11	Is the FMEA tool used in the design?
E12	Is there any design quality program being used?
F5	Is any centralized database being used?
F7	Is there any software for simulation of the Finite Elements Method being use?

Table 4 – Guidelines related to the Launching of New Products

D7	Is the information needed for new projects based on former projects?
D8	Has the company developed product for new market niches?
F6	Is any project management software being used?
G8	Are the products developed being certified by any external organization?
H4	Are the graduate professionals stimulated to make post-graduate educational programs?
H8	Are successful designs awarded or promoted?

5. THE INTERACTIVE CONCEPTION AND THE IMPLEMENTATION OF THE GUIDELINES

To characterize relations and interactions between the questions that were selected as guidelines, and that are lined up according to the four technological innovation factors, it was decided to apply a statistic boarding, where all the considered questions have been grouped, two by two, aiming to establish the association of a question with the other.

The considered questions are qualitative variable, because they all have, as possible results, an attribute (or quality) reflected in the answers (yes or not) given by the researched companies.

There is a process to organize the corresponding information to the qualitative variable. This process consists of summarizing the data in double entrances tables or contingency tables (Morettin and Bussab, 2005). In a general way, a contingency table is a representation of the data, qualitative or quantitative, that is, they can be classified according to two criteria.

The straightness of this association will be measured through the statistical test qui-square of Pearson (Montgomery and Runger, 2003). In the test of the qui-square the following hypotheses are considered:

H_0: The two analyzed questions do not possess correlations between themselves (they are independent);

H_1: The two analyzed questions possess correlations between themselves (they are not independent).

The construction of test of hypotheses has started on the presentation of the probability of the test significance, which a significance coefficient α, is defined as the probability of be mistaken when rejecting $\mathbf{H_0}$ and adopting $\mathbf{H_1}$ as true.

All the significance coefficients α can offer either a positive result (both questions are related to each other) or a negative result (both questions are not related to each other), as far as an acceptance level is defined.

5.1. Results from the qui-square test execution

From the qui-square test of Pearson (Montgomery and Runger, 2003), it is observed, in the Eq. (1), that:

$$E_{ij} = \frac{f_i \cdot f_j}{n} \tag{1}$$

The frequencies f_i and f_j are the corresponding relative frequencies to line i and column j, respectively. This indicates that, to get E_{ij}, it is enough to multiply the values of the line for the ones of the column, and divide them for the number of individuals in the sample.

It can be concluded that it has boundary-values for the product f_i . f_j. It is important to stand out that the condition $E_{ij} \geq 5$ always must be respected. This condition guarantees that the considered sample is not “vitiated” and, consequently, that the results of the test can be used to describe the population. If f_i . $f_j < n$, then $E_{ij} < 1$ and the addition that gives origin to the qui-square assumes high values. Thus, for the corresponding questions to these frequencies the considered sample becomes very small, and the boarding of the qui-square cannot be considered valid.

In the premise of the rejection of the hypothesis $\mathbf{H_0}$, the results of the test have been analyzed for the values of the significance coefficient α that measures the association between the questions.

In the procedure to test a hypothesis is being used a scale of evidences suggested for Fischer (Morettin and Bussab, 2005), and. Tab. 5 illustrates the scale of Fischer against $\mathbf{H_0}$ (or in favor of $\mathbf{H_1}$). The considerations of the Fischer scale mention the test of the qui-square.

Table 5 – Fischer’s significance scale (Morettin and Bussab, 2005)

α **(p-value)**	**0,10**	**0,05**	**0,025**	**0,01**	**0,001**
Nature of the evidence	**marginal**	**moderate**	**substancial**	**strong**	**strongly**

Using the statistical software MINITAB (Minitab Inc., 2005), it results, for the pairs of questions from the contingency tables, the values of the significance coefficient and, for the present study, through the qualitative boarding, the coefficients of significance up to 10%, that are considered important as test of correlation between two questions.

5.2. Priority on the implementation of the guidelines.

To cultivate the deriving attributes from the guidelines, the company must implement new technologies and methods of management, beyond resources of automation of the project process, as reply to the market needs.

Each one of these attributes, acting as an integrated form, contributes for small improving in the effectiveness of products development, that is contributing, in the magnifying of the capacity of technological innovation of industrial SME' s, improving its competitiveness.

As orientation for the implementation, this work organizes the guidelines in matrices, by factor of technological innovation. The requirements by the four technological innovation factors (component questions), are in the columns of the matrix. In the lines of this matrix there are other component questions that are correlated (α < 10%) with the requirements and that they can assist the company when the implementation of these requirements indicated for the columns.

Through the application of this table it is possible to get a proposal of priority of the technological methodologies and resources to be applied in the system of development of new products in the SME, contributing to the magnifying of its capacity of technological innovation.

It is presented as proposal of implantation priority the following correlations (Tab. 6).

Table 6 – Priority in the project best practices

Fundamental practice	**$0,0 < \alpha < 0,05$**	
Important practice	**$0,05 < \alpha < 0,10$**	

As far as this is a qualitative study, the correlated guidelines do not represent relations of cause and effect. They must be seen, therefore, only as guidelines contributing, that is, they are not necessary and not enough, but they can be associated with the effort for innovation in the company.

As an example, Fig. 4 presents the matrix with orientation for the implementation of the guidelines related to the efficient channels of information.

Correlated Questions		G.1 Do suppliers participate in the development process?	G.2 Do clients participate in the development process?	G.3 Are consultants hired to aid product development?	G.4 Are there any works being made with universities/research institutes?	G.7 Are the required tests done internally?	H.9 Are the PD department employees participating of international mechanical fairs?
D.7	Is the information needed for new projects based on former projects?					1,4%	
E.5	Is any national or international product development standard followed?	6,6%	1,1%		0,8%		
E.6	Is an internal development methodology followed?		6,1%				
E.11	Is the FMEA tool used in the project?		1,4%				
E.12	Is there any project quality program being used?		5,4%				
G.1	Do suppliers participate in the development process?		4,1%				
G.2	Do clients participate in the development process?	4,1%					5,3%
H.1	Is there any formal organization chart of the company that includes the PD department?		2,6%				
H.3	Is there any training policy for the employees?		2,0%				
H.4	Are the graduate professionals stimulated to make post-graduate educational programs?				9,2%	9,2%	
H.9	Are the PD department employees participating of international mechanical fairs?		5,3%				

Figure 4 - Matrix of implementation of the guidelines related to the Efficient Canals of Information

6. CONCLUSION

This work approaches a model of support for small and medium industrial companies, basing itself on the diagnosis of the companies about the four sets of technological innovation factors. This mapping, associated with the questions of the carried through research, will guide the effort of technological innovation, configuring it in guidelines for the products development in an innovative environment.

A set of guidelines, that show the best practices to follow in technological innovation and that offers support to small and medium companies of the metal-mechanical sector about selecting and generation of tools and technologies more applicable to the development of new products, according to their specific activity and contingencies, has for intention to provide qualification and chances with constant renewal for this category of companies, enabling them to stay and grow, in a highly competitive market.

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8. REFERENCES

CAMPOS, A.L.S., 2006, "Ciência, Tecnologia e Economia", In: PELAEZ, V; SZMRECSÁNYI, T. (Org.), "Economia da Inovação Tecnológica", Ed. Hucitec, Ordem dos Economistas do Brasil, S. Paulo, Brazil.
DINSMORE, P.C., 2006, "PMO & Best Practices", Mundo PM, n.3, ano 1, p. 38-40.
EDER, W.E., 1998, "Design Modeling: a design science approach". Journal of Engineering Design, v. 9, n. 4.
IBGE, 2004, "Pesquisa Industrial de Inovação Tecnológica: PINTEC 2003", Rio de Janeiro, Brazil.
KAMINSKI, P.C.; OLIVEIRA, A.C., 2004, "Desenvolvimento de Produtos e Inovação Tecnológica em Pequenas e Médias Empresas do estado de São Paulo". Escola Politécnica da USP, S. Paulo, Brazil.
LÜCK, H., 2003, "Metodologia de Projetos: uma ferramenta de planejamento e gestão", Ed. Vozes, Petrópolis, Brazil.
MINITAB INC. Pensilvânia, USA. 12 Jan. 2005, <http://www.minitab.com>.
MONTGOMERY, D.C.; RUNGER, G.C., 2003, "Applied Statistics and Probability for Engineers" Ed. Wiley, New York, USA.
MORETTIN, P.A.; BUSSAB, W.O., 2005, "Estatística Básica", Ed. Saraiva, S. Paulo, Brazil.
OLIVEIRA, A.C.; KAMINSKI, P.C., 2006, "Fatores de Inovação Tecnológica no Processo de Projeto de Produtos em PME`s Industriais", Proceedings of the IV Congresso Nacional de Engenharia Mecânica, CONEM, Recife, Brazil.
PLONSKI, G.A.; MUNIZ, S., 2000, "Competitividade e Aprendizagem Tecnológica e Organizacional: um elo indissociável", Proceedings of the XX Encontro Nacional de Engenharia de Produção, ENEGEP, S. Paulo, Brazil.

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