PROFILE CHARACTERIZATION OF THE PRODUCT DEVELOPMENT STRATEGIES IN THE SMALL AND MEDIUM ENTERPRISES OF THE METAL-MECHANICS SECTOR.

Paulo Carlos Kaminski
Escola Politécnica da Universidade de São Paulo
Av. Prof. Luciano Gualberto, Travessa 3 – nº 380
CEP 05508-900 – São Paulo – SP.
fone (55 11) 3091-5332
e-mail: pckamins@usp.br

Antonio Carlos de Oliveira
Faculdade de Tecnologia de Botucatu do Centro Estadual de Educação Tecnológica Paula Souza
Av. José Ítalo Bacchi s/n – Jardim Aeroporto
CEP 18606-855 – Botucatu – SP.
fone (55 14) 3814-3004
e-mail: antonio.c.oliveira@poli.usp.br

Abstract. *Product development management is widely seen as way of ensuring business survival through reduced releasing time, increased quality and reduced costs. In a research conducted by EPUSP's professors in partnership with FATEC's professors, a questionnaire was projected for to attain, in its content, the objective of presenting the vision of the small and medium enterprises concerning activity of technological innovation and, more specifically, with the product's development and its management. In this referred area of interest, the companies were identified by the activities' sector (metal-mechanic sector, focus of this proposal). In the field research, the professors visited 32 companies for the accomplishment of the information's survey, over a period of four months. Research produced a great quantity of information, which is being analyzed. Preliminarily, this work will present the result of one of the answered questionnaires, that tries to answer a specific question: "The development process generates more evolutionary or more innovative products"?*

Keywords: product development, design methodology, product strategy, product innovation, technological innovation.

1. Introduction

A current situation that confronts mostly small and medium enterprises introduces itself as a technological rupture, when these companies come across the challenge of modifying the way their business were always done. It is very difficult for an established company to keep itself in the market leadership when a rupture arises, because a bet on new technologies demands renounce from efficiency to which one is used to. The companies need strategies to control that risk. Change for a new technology demands resources' allocation, supported by a strong methodology.

In a recent research (Kaminski, Oliveira, 2004), this aspect has shown itself not exactly as the result of an action planned in most of the companies. The subject causes preoccupation because it can provide immediate results, in the maintenance and increase of the clients' base, or in the long term, in the clients' attitude regarding its products. Therefore a better planning of the product should be practiced because it is worthwhile, and generates profit.

The guidelines' planning and establishment of what needs to be done becomes important for the product, right from the start of its development process until its introduction in the market, to guarantee that it exhibits, with success, the qualities that the consumer wishes to find. For that, it is necessary to exist a clear strategy for development programs of new products, widely divulged, aligned with the global strategy of the company, with goals and allocations of very defined resources.

Nowadays companies have in disposition many and diversified tools to lead its plans and actions of product development: from scientific methodologies that gather detailed procedures, to ethnographical researches that intend to trace with exactness the clients' profile until the possibility of checking, in real time, the sales' position of a determined product in the market. These tools form an armory that technology helps to make possible and that, in thesis, would enable to transform any company in a sales' and incessant profits' machine. But the paradox is that, although wide knowledge is accumulated in the development area of the product, many of the new products still fails and the companies continue to lose clients, because the multiplication of the tools contradicts with its low utilization level, evidenced in the research with small and medium enterprises.

The referred research, conducted by professors of EPUSP in partnership with professors of FATEC, has sought to evidence the development strategies existence of new products, both in corporative global level as in product level, that is, of each accomplished project, allowing the vision of the small and medium enterprises concerning the activity of technological innovation to be shown.

2. New product development strategies

In a business environment where the companies should be more and more flexible to answer quickly to competition and market changes, to seek new managerial strategies continually, using them as base or reference to generate and to aggregate new knowledge of a more efficient way has become a paradigm for the success.

The knowledge also includes the capacity of innovating, and the technological innovation is a decisive strategic factor, in this fast changes scenario.

The scientific advances, which enlarge the relevant knowledge in a worldwide basis, are actually far from any innovation that aggregates value on products and makes them more competitive (Nicolsky, 2001), because there is an essential difference of the process of scientific research, typically accomplished in the academic environment, which aims human resources' formation and the consequent generation of new knowledge, to the process of technological innovation, an economic action by essence, accomplished in the industrial production environment, and which objectives fundamentally competitiveness, market enlargement and, at last, profit.

Regarding the technological innovation, a precise concept is introduced by Valeriano (1998) as "a process in which an idea or invention is transposed for the economy or, in other words, runs through the course that goes since this idea was elaborated, making use of existing technologies or researched for this use, until creating a new product, process or service and placing it in availability for consumption or use".

The author defends the importance of technological innovation to be imagined as a process and suggests that, for a better comprehension of the product development activity, it is important to know how it inserts itself in the process of technological innovation.

The procedures entitled as new product development methodologies were created to aid the creative process and the prescription and progressive following of criteria that command since the generation phase of the idea that comes to answer needs in consumption, real or planned, latent or apparent, until this new product can be launched.

The product development process is by itself the creative integration of technology, scientific information and knowledge of the consuming market, where the design activity in engineering is inserted.

According to Clark and Wheelwright (1993), the product development is a process in which an organization transforms information of market opportunities and technical possibilities in production information for a commercial product. That way, this process goes beyond the product design, including relationships with other sectors of the company like production, marketing and logistics, and with the external environment of the company, like the market.

Calderini and Cantamessa (1997), researchers of Turin's Polytechnic University, investigating factories of that industrial region, conclude about existing evidences regarding the essence of the innovation process in small and medium companies, in the project and product development phases, and will depend on its ability of making flexible enough its integration both with clients and suppliers and partners.

In a more recent work, researchers of the university of Pisa, Italy, accomplished a study involving 47 small and medium Italian companies, with focus in the innovation area of the product, relating it at improvement in products and process, through its intellectual capital, restraining elimination of the ability to innovate, enlarging flexibility, generating management opportunities that, according to the research, in most cases were unknown in this companies' category (Corso *et al.*, 2003).

In Brazil a extensive and detailed survey accomplished by a team of the Federal University of Sao Carlos (Toledo, 2002), reveals that even though all the companies of the sample affirm to adopt a model of formal reference for the process of product development (PPD), 26% do not yet use performance indicators to evaluate that process, evidencing the need of evolution of the practiced administration, adding performance evaluation and learning indicators and systematic.

Thus, the investigation on the utilization of product design methodologies, in the small and medium enterprises of the metal-mechanics sector of Sao Paulo, valuing and divulging its best practices in the product innovation, makes its merit justified and opportune.

3. The Research

The present research is classified as an exploration, a description and with a qualitative approach; the Survey Research method was utilized.

A questionnaire was developed as a way to obtain the vision of small and medium enterprises regarding Technological Innovations and more specifically, Product Development and its management.

Afterwards, some of the participant enterprises were selected by size (formal classification as small or medium enterprise) in Sao Paulo and its outskirts, as well as in Sorocaba's administrative region. Then, the enterprises were identified by activity sectors (metal-mechanics sector is the focus of this research) and type of product (related to the suggested profile in this project).

Concerning questionnaire form, a document conducted by open questions, closed dichotomous questions or multiple choice questions was chosen to provide facts or actions of the enterprises, filled directly up in the document.

Basically, the applied questionnaire consists of three blocks: the first one has questions to character the enterprise and the work section of the interviewed professional; in the second one, questions take direction to know the working method adopted by the enterprise in Product Development; finally, the third block is addressed to general evaluations.

In the field research, researchers visited 32 enterprises in quest of the desired information, during four months. The collected data using the Evaluation Questionnaire consisted in a procedure of personal interview with the responsible professional (Director, Manager, Chief) for Project Sectors, Product Development Sector or similar sectors in the enterprises, making clear that the purpose and use of the questionnaire were only academic.

In the sequence, results were analyzed. This step was a evaluation of the obtained results, systematization and classification of information, statistic data work and the consolidation of obtained results into a data base.

Table 1 shows the initial establishment of data determination (in the sample of 32 enterprises) related to the characterization of enterprises.

Table 1. Consolidation of data about the enterprises' characterization (Questionnaire A)

A.1 – Number of Employees	0 to 99	100 to 499	500 or more
Total	13	16	3
A.2 - Annual Invoicing (US$ Mi)	Till 3,5	From 3,6 to 20	Up to 20
Total	13	12	7
A.3 – Composition of Enterprise's Funds	National	Foreign	Mixed
Total	27	5	0
A.4 – Activity Area or Secction	Pieces / Automotive pieces	Equipments / Machines	Others
Total *	6	16	16
A.5 – Activity Market	National Exclusive	National Predominant	International Predominant
Total	14	17	1
A.6 – Does it have a ISO 9001 Certificate?	Yes	In progress	No
Total	17	3	12
A.7 – How many competitive enterprises acting in market?	0 to 9	10 to 14	15 or more
Total	25	4	3

*Note: Some enterprises act in more than one sector; therefore, summing totals are more than 32.

The general data analysis shows that, referring to size, there was a distribution between small and medium enterprises; according to the criterion used by SEBRAE[1], (considering the number of employees) the research's universe presented 40% of enterprises classified as small enterprises – "micro-enterprises" were not evaluated, for none of the participants presented less than 20 employees.

What refers to the annual invoice criterion, it was decided to use the classification of the "Banco Nacional de Desenvolvimento Econômico e Social" (BNDES) (National Bank for Economical and Social Development), the same used to determine special financing lines in Brazil. In this item, the research universe presented 40% of enterprises as small ones too. Enterprises with annual invoice up to US$20 Million (that's to say they would be considered large size enterprises) keep attending to the research target, being included into the assortment by its number of employees.

4. Initial Results Presentation

The research produced a lot of information to be analyzed: for example, its relations to software used as basis to the department, software of numerical computation, simulations and project; also to management of automatized resources of information technology, technical access to Internet, CAD tools, among others (Kaminski, Oliveira, 2005).

This article will present the results of one of the answered questionnaires that relies on the specific question "The development process bring more evolutionary or more innovative products?", which composes the Questionnaire D. For this presentation, some items were placed in categories, as follows.

Consolidating the obtained results for the initial question, "How market needs are obtained?" (D1), it was noted that for the majority of enterprises (86%), information is provided by their clients. But these informations take many different ways until they are effective applied in product development.

Enterprises involve its commercial area directly (28%) to get knowledge of market needs, as well as their net of resellers that pass along information initially to the commercial area (12%), their technical assistance area (14%), their marketing area through researches (6%) and their development product area by direct contact with clients (26%). The acquisition of information was detected also through fairs (8%) and analyzing competitors (6%) – but in a less expressive way.

Figure 1 shows the main forms of obtaining the market needs.

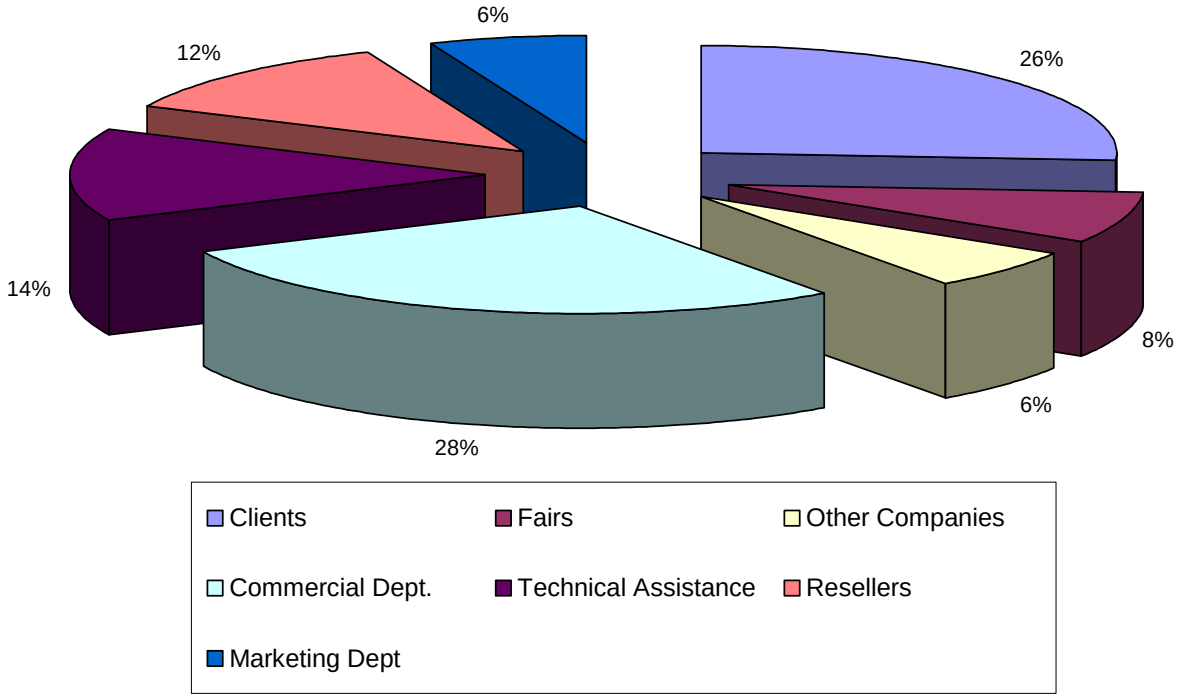

Figure 1.Obtaining market needs (D.1)

Making open questions such as "Introduction on the market, stability on market, utility life, retirement and time to product development" (D2 to D6) brought many diversified answers, written into each company's own terminology and perception of the interviewed. If the interviewed didn't know the complete information, it was remarked as "no answer" in questionnaire; if it was answered in a general way (much, many, etc.), the appointment kept this perception. Table 2 presents answers consolidated by enterprise.

The identity of enterprises in Table 2 was substituted by numbers, according to the request of the interviewed that their enterprises would not be standing out individually or directly related to the answers.

Table 2. Product Behavior (D.2 to D.6)

Company	D.2. How many new products are introduced on the Market per year?	D.3. How many years do the products stat in the Market? (years)	D.4. Which is the estimated utility life for the product (time of use by consumers)? (years)	D.5. How many products are taken away from the market per year?	D.6. How long does the development of a new product takes? (months)
1	5	15	10	3	3 to 24
2	many	no answer	no answer	no answer	no answer
3	1	8	10	0	12
4	50	3 to 5	5	50	2.25
5	2 or 3	8	10	0	2 to 3
6	10	0.5 to 30	3 to 20	100	0.03 to 0.33
7	70	10	10 to 15	35	3
8	0	10	10	0	0.33
9	0	18	15	0	1
10	many	10	10	0	6
11	180 to 300	5	2	10	2 to 4
12	3	10	10	0	6
13	100	20	10	10	0.03 to 24
14	0.5	10	10 to 12	0	2
15	no answer	no answer	0.5	0	0.25
16	2 or 3	10	5	0	12 to 15
17	1	5	20 to 30	1	4 to 8
18	5	45	10 to 30	0	3 to 6
19	2	5 to 20	10	0.5	1
20	15	10	20	0	24
21	50 to 100	6	3	50	3 to 4
22	8	5	5	0	1
23	112	5	5	0	1 to 6
24	36	no answer	30	0	1
25	10	10	10	5 to 10	2 to 3
26	3	10	10	0	6
27	15	10 to 25	10 to 15	few	3 to 6
28	1.6	8	10	0	1 to 6
29	5	10	10	0	4 to 6
30	2	5	4 to 5	1	0.4
31	0.5	5	4	0	2 to 6
32	3	6	10	1	10 to 12

The strategy for new product development can be observed in the dichotomous questions (D7, D8 and D9) presented in Table 3.

Adopting new production processes (a procedure identified in 56% of enterprises) to get new market niches (intention declared by 78% of enterprises) does not turn into a helping hand for the development process – it becomes more difficult to innovate: products are, then, more evolutionary. This premise is reinforced when 87% of enterprises based their information for new projects in former projects.

Information about market's needs follows different ways until its effective use in product development, as presented in Figure 1: they are basically processed through the commercial area with clients and can justify the apparent lack of connection in data about quantity of new products, how long they stay in market and quantity of retired products; that leads to incompatible data too, if utility life of product is appreciated.

This scenery presuppose the lack of planning as a whole for these activities.

Table 3. Strategies for new products development.

	Are necessary information to new projects based on – in its majority – former projects? (D7)	Does the enterprise develop products for new market niches? (D8)	Are new production process used? (D9)
Yes	28	25	18
No	4	7	14

5. Statistical approach and result analysis

The research is essentially qualitative and has produced an enormous amount of records. Its informations were grouped to make the data analysis easier, as presented in the former topic. For some closed questions, dichotomous or polychotomous, the researchers chose to make an statistical approach, in order to establish if there is any sort of connection between questions, grouped two by two. The intention of this approach is to determine if there is any association between aspects of management with the companies' economic performance identifying parameters of the product development area that imply and/or accelerate a process of technological innovation.

One of the main goals of building a conjoined distribution of two qualitative variables is to describe the association between them, that is, to know the degree of one's dependence to the other. That way, the result of one of them is better predictable when the pattern of the other is known (Bussab e Morettin, 2005).

In a general way, the quantification of the relationship degree between two variables is made through association or correlation coefficients. The initial statistical approach will make use of Pearson's Chi-Square Test (Costa Neto, 1977).

5.1. The chi-square test

When there are two qualitative variables of interest, the tabular representation of its' observed frequencies can be made in a very simple form, through a contingency table of two entrances.

A very common question is whether the involved qualitative variables are independent between themselves or not. That is, the following hypothesis can be tested:

a. H_0: the variables are independent;
b. H_1: the variables are not independent, that is, they present some degree of association between themselves.

This test can be made by χ^2 ("*chi-square*"), that is, by the following quantity:

$$\chi_\nu^2 = \sum_{i=1}^{r} \sum_{j=1}^{s} \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}} = \sum_{i=1}^{r} \sum_{j=1}^{s} \frac{O_{ij}^2}{E_{ij}} - n$$

Where:

χ_ν^2 is the test's statistics, with ν degrees of freedom;
r is the number of rows in the contingency table;
s is the number of columns in the contingency table;
O_{ij} is the observed frequency (number of individuals) in the intersection of row *i* with column *j*;
E_{ij} is the expected frequency (number of individuals) in the intersection of row *i* with column *j*;
n is the number of elements in the sample.

Each cell's expected frequencies are calculated by:

$$E_{ij} = n \cdot p_{ij}$$

Where:

p_{ij} is the probability of one observation in the considered cell being made.

If there is independence between the variables, according to the H_0 hypothesis:

$$p_{ij} = p_i \cdot p_j$$

Where:

p_i is the marginal probability corresponding to row *i*;

p_j is the marginal probability corresponding to column *j*.

As the marginal probabilities are not known, they can be estimated through the correspondant relative frequencies:

$$p'_i = \frac{f_i}{n} \qquad \text{e} \qquad p'_j = \frac{f_j}{n}$$

Resulting:

$$E_{ij} = n \cdot p_i \cdot p_j \cong n \cdot p'_i \cdot p'_j = n \cdot \frac{f_i}{n} \cdot \frac{f_j}{n} = \frac{f_i \cdot f_j}{n}$$

Which is the practical rule for the calculation of the expected frequencies: multiplying the totals of the line by the totals of the column and dividing by the number of individuals in the sample?

The number of degrees of freedom ν that the variable χ^2_ν must be tested can be calculated through the following form:

$$\nu = (r-1)\cdot(s-1)$$

It is important to introduce the concept of significance index α (or "*p-value*"), nothing more than the probability of error when rejecting H_0 and adopting H_1 as real.

After the calculation of the statistic χ^2_ν, it must be compared to $\chi^2_{critical}$, represented in a table, function of ν e α. If $\chi^2_\nu > \chi^2_{critical}$, H_0 is rejected with the percentage of significance given by α. That implies that exists the percentage α of making a mistake when affirming that H_1 is true.

With this test, it is possible to also calculate, given the contingency table, the correspondent α ("*p-value*") for the hypothesis test. In order to do so, the value of χ^2_ν must be entered on the distribution table χ^2. With ν, α is obtained.

As an example for the presented questionnaires (A and D), table 4 considers the construction of a contingency table between questions A.2 and D.9.

Table 4. Contingency table between questions A.2 and D.9

		Annual invoice (A2) (US$ million)			Totals
		Until 3,5	From 3,6 to 20	Above 20	
Are new fabrication processes being used? (D9)	Yes	3	10	5	18
	No	10	2	2	14
Totals		13	12	7	32

The chi-square test was applied in the contingency tables formulated with the closed questions of questionnaires A and D (A2, A3, A5, A6, D7, D8, D9). Question A4 was not used, for it received more than one answer per item, altering the size of the sample.

Softwares such as MINITAB calculate α ("*p-value*") automatically, given the appropriate contingency table.

In the case being studied, we have the following hypothesis:

- H_0: there is no correlation between the questions (independents);
- H_1: there is correlation between the questions.

Analysing at 10% of significance ("p-value"= α = 0.1):

- If α <0.1: there is correlation;
- If α >0.1: there is no correlation (independents).

The results are shown in table 5:

Table 5. Results of the chi-square test using MINITAB

	D.7	D.8	D.9
A.2		0,854	**0,002**
A.3		0,309	0,682
A.5		0,419	**0,002**
A.6			0,364

Where:

x,xxx	Positive answer (Questions are correlated with 10% error margin)
x,xxx	Negative answer (Questions are not correlated with 10% error margin)
	Chi-Square approximation probably invalid

It can be said that, with an error margin of 10%, A2 and D9, as A5 and D9, are correlated.

6. Conclusions

The identification of the existence of problems of knowledge transfer over the methodological aspects of product development can make the companies understand their repercussions and benefits, increasing effectively it's competitivity.

The research has produced data that will allow a better understanding of the innovative dynamics and the characteristics of small and medium enterprises. These data can be used by a series of institutions involved with the industrial development of the state of São Paulo, in order to produce knowledge, divulgation and application in a systemic form, for both the use in companies and for the academic use.

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