New product development process: a survey of best practices

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Abstract
This paper aims to identify the main contributions of international and national studies investigating the relationship between organizational practices for new product development process (PDP) and the success with innovations. This study was made based on papers published in leading journals. The paper presents and compares the best practices identified.

Keywords: Best Practices, PDP Organization, Innovation.

Introduction
In the current scenario, innovation and knowledge become increasingly important for the competitiveness and survival of the productive organizations. The innovation may be related with technology, product, production process, organizational arrangement and further including the business model.

Specialized companies can lose market and become vulnerable in a complex environment with high variability of demand. To increase competitive advantage, a company depends on product diversification, even though it may represent a loss of productive efficiency at first. This diversification occurs via innovation process, which depends on the capacity to generate knowledge by the company.

Mechanisms of destruction of competition through unequal competition or monopolies achieved through protectionist mechanisms, generate results over a period of time, but do not guarantee the survival of these companies in the long term (Penrose 1979).

Competition through innovation replaces traditional forms of competition, a process that (Schumpeter 1942) called "creative destruction." This form of competition has driven business growth and economic development in different countries.

(Penrose 1979) has reported that this process of "creative competition" became dominant in the behavior of many U.S. industries, ensuring their growth.

The important role of innovations for the very survival of businesses boosted research for the Product Development Process (PDP), giving rise to different techniques, methods and organization strategies of the process of new product development, aiming to increase efficiency process, increase skills, reducing development time and product launch in the market, among other factors.

This paper identifies and analyzes some of the key practices of the organization process of new product development (NPD) and the success achieved by innovative companies, from researches and studies in the scientific literature.

The paper is organized into 7 sections and in section 2, it is made a brief discussion on the linear and systemic innovation models. In Section 3 are exposed organizational structures found in companies committed to innovations. Further, the forms of the PDP organization are discussed in section 4. Section 5 discusses the importance of management of new products R&D and strategies with R&D teams. Section 6 presents the competencies required in the generation of innovation and in section 7 concluding remarks are made about the work.

Linear model and systemic model of the innovation process

The linear model of innovation has been widespread since the end of World War II, among researchers who sought to explain the process of developing new products. This model was based on the ideas contained in the report "Science - The Endless Frontier" by Vannevar Bush, director of the Office of Scientific Research and Development, established in 1945. Vannevar Bush defended the premise that new knowledge and innovations arose from the basic science and that only by investing in basic science could achieve technological progress. This view of science resumed the ideas of Francis Bacon in 1635 and had great influence on science policy for two decades after the year 1945 (Metcalfe 2003).

This model provides a simpler view of the innovation process and states that the process steps brings distinct and defined stages, and a single sequential order, starting with basic research, development, production and marketing, as shown in Figure 1.

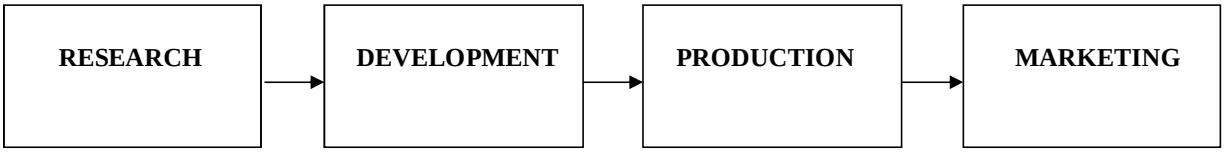

Figure 1 - The linear model

The linear model is controversial and one of the controversies is that the technology would hierarchically be less important than science and, according to this model, the technology was applied science. Under the assumptions of this model, new scientific knowledge emerges in proportion to the investment of resources in basic research (Metcalfe 2003).

The linear model is still widely used in analysis and discussions, particularly on political issues. According to (Kline and Rosenberg 1986), one of the flaws of the linear model is that it does not consider the opinions and expectations of customers, i.e., it does not consider the feedback to the sales area, the fundamental analysis of product performance and does not review the design or design to generate better versions.

The linear innovation model does not consider the importance of feedbacks from the market at any stage of the innovation process and the different sources of innovation, which are not necessarily related to basic research or scientific research.

According to (Kline and Rosenberg 1986), the thesis that innovation begins with research is wrong in most cases. For the authors, the stage of the project or design is considered the initial step of the innovation process and not science. The redesigns generate innovation and depend in many cases, of the contribution of other areas of knowledge. The research may contribute to generate a solution to a problem that prevents an innovation from being completed. Much research into new materials was generated from problems encountered in the creation of new

products, such as semiconductors, solar batteries, steam turbines and others. Thomas Edison to develop the electric lighting system required the analysis of a mathematician to solve problems related to parallel circuit (Kline and Rosenberg 1986).

Regularly, the linear model was superseded by other interactive and systemic models, considered more suitable for the analysis of the innovation process of companies.

One of the models with more systemic approach of the innovation process is the interactive model (chain-linked model), proposed by (Kline and Rosenberg 1986). This model considers the feedbacks between the various stages of the innovation process. In this model, the firm is the main source of innovation and not the university or research institutes. There is also interaction with other companies and with the science and technology environment in which the company operates. Figure 2 illustrates this interactive model.

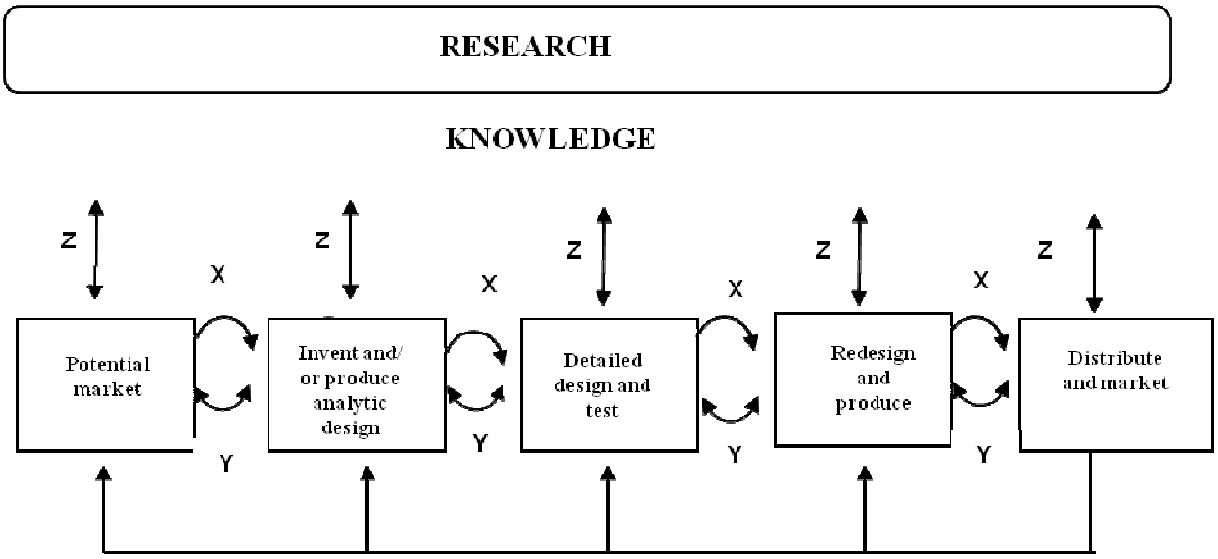

Figure 2 – The chain-linked model

According to the model, the relationship between the firm and the research can occur at any stage of the innovation process. The authors identify some possible paths of innovation: a central path starting at the project of an invention through the other steps until you reach the market (letter x); a path of feedbacks that can occur at each stage of the process (upstream and downstream) and from the market (letter y) and a path search to be incorporated by firm or otherwise, from a firm's demand to generate a new research (letter z).

In this model, the early innovation does not always occur from basic research to achieve technological development, as occurs in the linear model. In the interactive model the company builds internal relations, establishes external linkages with other companies and also there are interactions between science and industry in isolation, to develop products, processes or services. The company seeks opportunities for innovation from the needs raised in the market, when using scientific knowledge already available internally or, if necessary, triggers the scientific starting a new search.

(Schumpeter 1939) highlights that invention differs from innovation, because just when an invention is commercially developed and reaches the market, it becomes an innovation (OECD 1997).The innovation on product or process seeks to meet performance levels desirable,

still subject to cost constraints, since the activities of designing new products are very sophisticated and very expensive (Nelson and Rosenberg 1993).

(Schumpeter 1939) proposed a classification of various types of innovations incorporated in the Oslo Manual, which provides guidelines for the collection and use of data in research on technological innovation in industry (OECD 1997). In Schumpeter's classification, the types of innovations are:

- Introduction of a new product or a qualitative change in existing product;
- Process innovation that is new to an industry;
- Opening of a new market;
- Development of new sources of supply of raw materials or other inputs;
- Changes in industrial organization.

Innovation is also classified according to their size in terms of degree of novelty, as incremental or radical (Tidd et al. 2005). According to (Tidd et al. 2005), incremental innovation occurs when an existing product or service undergoes improvements or upgrades, on the other hand, radical innovation is when an entirely new product or service arises market, involving changes in thinking and use these products or services.

(Tidd et al. 2005) presented the model classified as the "4Ps" and define innovation in terms of product, process, position and paradigm, considering also the innovations in services:

1) Product innovation - changes in products or services that an organization provides;
2) Process innovation - changes in the way products and services are created and distributed;
3) Position innovation - changes in the context in which products or services are introduced and
4) Innovation paradigm - changes mental models that underlie what organizations do.

In evolutionary theory the concept of innovation is treated comprehensively as "a process by which firms master and turn in practice, the prototypes of products and production processes that are new to them and not necessarily to the universe or a nation" (Nelson and Rosenberg 1993).

The process of innovation is to be treated as a social process, with the contribution of different actors and organizations, carriers of knowledge and skills that complement each other to generate innovation. This interactive approach and dynamics of the innovation process is a neo Schumpeterian approach, which considers better all the complexity involved in the dynamics of innovation.

Structural forms taken in product development process

The need to increase the efficiency of the PDP, increasing skills, improving project quality and reducing development time and product launch in the market, among other factors, has led companies to search and development of different practices and forms of organization of PDP.

One of the factors that affect the efficiency of the PDP is the organizational structure adopted by the company.

Different studies have been conducted to identify the types of structures used in various organizations both in manufacturing and in the services sector (Johne and Snelson 1988, Larson and Gobeli 1988, Mintzberg 1995, Vasconcellos and Hemsley 1997).

The structural form of an organization can reveal important aspects of how work is performed, as well as other aspects of the distribution of authority, forms of communication rules and information, coordination of activities, forms of cooperation, among others.

The traditional structures are found when activities are very repetitive and the environment is stable. (Vasconcellos and Hemsley 1997) highlight that the main features of traditional structures are: high level of formalization; control unit; employees highly specialized; vertical communication; traditional forms of departmentalization.

For complex environments and large changes like this in which organizations are embedded in the present moment, traditional structures are not adequate, resulting in more flexible or organic arrangements, such as matrix structures or project oriented. There are different types of organizational structures adopted by companies involved in the development process of innovations.

(Larson and Gobeli 1988) in a large study analyzed the types of organizational structures adopted by companies involved in R&D of new products and identified five types of structures, taking as reference the work of Galbraith of 1971. The structures related by the authors are: the functional structure, the functional matrix, balanced matrix, project matrix and project team. A brief description of those organizational follows:

1) Functional - the project is divided into segments and assigned to functional areas,
2) Functional matrix - a project manager with limited authority coordinates the project through different functional areas or groups. Functional managers have responsibility and authority for their areas of expertise in the design,
3) Balanced matrix - a project manager oversees the project and shares the responsibility and authority for project completion, with the functional manager. Functional managers and project run together work areas and make decisions,
4) Project matrix - a project manager oversees the project and has responsibility and authority for completion. The functional manager is responsible for allocating staff with technical knowledge,
5) Project team - a project manager is responsible for the team, composed of professionals from different functional areas or groups that operate outside organizational boundaries to complete a project. The functional manager has no formal involvement.

(Vasconcellos and Hemsley 1997) found the main features of the innovative structures:

(a) Low level of formalization - because in complex environments new problems arise;
(b) Advanced forms of departmentalization - by profit centers or units with great autonomy, usually in large groups with very diverse activities or products; departmentalization for projects, highly effective against environmental changes; departmentalization matrix that simultaneously uses two or more types of departmentalization; structure cell that is fully flexible and structure to "new ventures" that separates new activities from routine activities or operations;
(c) Multiplicity of command - when one or more integrated projects involving experts from various technical areas, generating double or multiple subordination of these specialists to their managers;

(d) High diversification - professionals have diverse knowledge in various technical areas;
(e) Horizontal and diagonal communication - in dynamic environments need to communicate more often between specialists in different areas.

One type of structure pointed by many authors as one of the most found in R&D activities is the structure for projects with greater diversification of technicians, which allows further reduction of the idleness among projects. In this type of structure, workers exchange experiences and cooperate with workers from different areas, knowing the relations between areas and having an overview of the project set, which is not possible with a functional structure (Larson and Gobeli 1988, Vasconcellos and Hemsley 1997).

According to (Johne and Snelson 1988), the functional structure is ideal for activities more stable and not for activities involving continuous change, as innovative activities.

In the project structure there is a change in the composition of teams for each new project, which allows a greater range of activities and more interaction between different people in related fields. According to (Vasconcellos and Hemsley 1997), these features of the structure for projects generate greater satisfaction for technicians, besides being an opportunity for improvement.

(Vasconcellos and Hemsley 1997), point that one of the biggest disadvantages of the functional structure is the separation between functional areas with the expertise of technicians and so they can't work together. In the structure of projects, the team is multidisciplinary and works in conjunction with high interaction throughout the project execution.

The type of organizational structure adopted by a company impacts on some indicators of efficiency, since some structures generate greater flexibility than others, enabling lower costs, greater communication between people, greater autonomy to professionals, agility in making decisions and solving problems, among others.

There are several studies in the literature on the impacts of organizational structures in research and development of innovations and many models focusing on the steps of the development process. In general, the studies are focused on the determinant factors of financial performance and the success of innovations, focusing on improving aspects of process steps, reducing costs, improving communication between team members, mechanisms and strategies for coordinating activities (Brown and Eisenhardt 1995).

Organization of activities in R&D process

The process organization of R&D is seen as a critical factor to the success of launching an innovation in several studies analyzed for this article (Brown and Eisenhardt 1995, Cooper 1979, Cooper and Kleinschmidt 1986, Griffin 1997, Kahn et al. 2006, Takeuchi and Nonaka 1986).

The research of (Cooper 1979) is one of the first to identify the critical success factors in developing a new product, in which the author has mapped the main activities involved in the PDP process.

(Cooper and Kleinschmidt 1986) based on the work of (Cooper 1979), identified the most important activities in the development process of a new product, as successful companies use formal procedures and clear criteria. (Kahn et al. 2006) also highlight the process organization of R&D, as one of the success factors of innovative companies.

According to (Cooper and Kleinschmidt 1986), the success of a new product development depends on some key activities and how these activities are well executed and integrated to the process, i.e., people are the most important asset to the success of new products. The type of technology, the nature of the market or the synergy between design and business are important,

but not sufficient, because are the people who perform the activities and contribute strongly to the success of the project of the new product.

(Cooper and Kleinschmidt 1986) present key activities, which can lead to a successful new product, if developed with quality that includes:

1) Initial selection;
2) Preliminary market assessment;
3) Preliminary technical assessment;
4) Detailed study of the market;
5) Financial/business analysis;
6) Product development;
7) In-house product testing;
8) Product test by the customer;
9) Test market/trial sale;
10) Trial production;
11) Business analysis of pre-marketing;
12) Production start-up;
13) Market launch.

(Cooper and Kleinschmidt 1986) state that the new product development process is deficient in many companies. While managers say they have a systematic planning process, the authors identified many gaps and deficiencies. Some critical activities are omitted and other key activities are partially developed.

According to (Cooper and Kleinschmidt 1986), an analysis of the results of what actually happens in 203 projects surveyed reveals that many activities or internships accepted or prescribed in the project, are completely omitted in the actual process. Only 1.9% of the projects executed all the 13 activities. In the majority of projects studied, less than 9 of the 13 activities were carried out. In another outstanding work, (Cooper and Kleinschmidt 1995), suggest that it is important to focus on pre-development activities, with emphasis on technical studies, market analysis and feasibility of the product. (Griffin 1997) already pointed out that the most important activities are the generation and analysis of ideas, technical development and marketing.

According to (Cooper et al. 2004), all activities of pre-development, development and post-development are critical to the success of a new product.

New product development project teams

Several authors emphasize the importance of the R&D project teams, to improve process performance, information exchange, increase skills and integration of the various activities involved (Brown and Eisenhardt 1995, Edmondson and Nembhard 2009, Griffin 1997, Kahn et al. 2006, Takeuchi and Nonaka 1986).

(Brown and Eisenhardt 1995), highlight the importance of the project teams for the performance of R&D, with cross-functional teams, who are responsible for the development of all activities of R&D. These are concepts that transform, vague ideas and product specifications on new products. According to the authors, composition, group process and the organization of work in project teams affect the information, resources, and style of problem solving teams, which in turn influence the performance of the process, i.e. the speed and process productivity. The composition of the teams, with people of different qualifications, the figure of a facilitator in

the good teams and the good relationship between the members are identified as critical to the performance of the process (Brown and Eisenhardt 1995, Griffin 1997).

(Takeuchi and Nonaka 1986), analyzing the process of developing new products, highlight the importance of the factors flexibility and speed for the development of innovations and claim that some structures and ways of organizing R&D activities jeopardize the efficiency of these factors, as the sequential traditional way.

In the traditional approach of product development, a project has multiple phases with a group of functional specialists working in each of the project phases (concept development, testing, product design, development, pilot production and production for the market). When a group finishes its step, the job goes to the next to be continued (Takeuchi and Nonaka 1986).

(Takeuchi and Nonaka 1986), studying companies in the United States and Japan, showed that these companies have begun to treat the product development with a holistic approach, which the authors compare with the “Rugby” in which the team works together, passing the ball back and forth according to the chosen tactic and not in stages or sequentially. In the method "rugby", there is a constant integration and a multidisciplinary group and the members work together from beginning to end and not piecemeal structured and defined, but overlapping. Thus, a group of engineers could start the design of the product, before the tests were finished. Companies like Honda, Canon and Fuji Xerox worked with this method that seeks to encourage experiment and error, challenging the status quo. According to the authors, this method stimulates new ways of learning and thinking in companies at different levels and functions, and can break the rigidity of the companies.

(Takeuchi and Nonaka 1986) examined new approaches in managing the process of product development by companies such as NEC, Honda, Epson, Brother, 3M, Xerox and HP. The authors identified in leading companies, six characteristics in managing new product development process: construction of instability; self-organized project teams; overlapping development phases; multiple learning; subtle control; organizational transfer of learning.

Skills required for innovation

In addition to the practices, techniques and ways of organizing activities related to the R&D of new products, highlights the importance of skills of the companies involved with innovation.

According to (Munier 2006), the company develops skills to innovate and innovation itself ends up generating new skills in the company. Innovation generates feedback and involves internal and external interactions with different modes of learning. The author highlights that skills are important for company adaptation to the environment for the innovative process. These skills are related to the production process, marketing, human resources management, financial, among others.

(Munier 1999), in his extensive study of companies innovation practices in France, identified four groups of competences that a company should have to innovate: technical competences; organizational competences; relational competences and competences of means.

(François et al. 1999) consider that the skills can be complementary and that there may be a hierarchy of competencies, in which one is more important than another. Among the industrial sectors there are differences about the degree of importance of a particular competence to innovate, i.e. a competency can be critical to a sector without significant importance to another.

(François et al. 1999) relate and define the competencies that can be identified in the companies through questionnaires and allows assessing the degree to which these skills are developed and deployed in enterprises. If a company has not developed quite a skill, it can get in the external environment through a supplier or service provider, for example, the management of

intellectual property, which is one of the important skills to innovate. The company can hire a lawyer with knowledge of patents in the country and abroad. The competencies identified by the authors relate to the areas of: management and organization of human resources and material and operations management. The competencies identified by (François et al. 1999) are grouped into:

- Management and organization of research in innovation;
- Review the company ability to transform;
- Managing communication between different levels of the structure;
- Identify new needs and opportunities related to products and processes;
- Identification and appropriation of technologies from the external environment;
- Management of intellectual property;
- Introduction and rapid diffusion of an innovation;
- Monitoring of updates and developments of competing products in the market;
- Commercialization of an innovation;
- Identifying ways of funding and sponsors of an innovation.

Conclusion

This article covered the concepts of best organization practices of the development process of new product (PDP) and the success with innovations, presenting a summary of some studies and research that examined the relationship between best organization practices of the PDP and success of innovations.

The survey was done within studies in main journals, databases found in the "Web of Science". The results showed that the main organizational practices of the PDP can generate successful launch of new products by firms involved with innovation.

It was noted that this relationship is of fundamental importance for companies and researchers involved in the generation of innovations, given the return and competitiveness achieved by the companies surveyed.

As seen in previous sections, one of the factors related to successful innovation is the choice of model to be implemented, linear or systemic, which has advantages and disadvantages, depending on the business type and sector of the company. Another factor related to successful innovation and much investigated by the researchers, is the choice of how to organize activities related to the PDP and defining the major steps or phases. The organization of teams of R&D of new products and strategies to manage the teams is themes fairly investigated in the academic literature and, finally, highlights the importance of the skills required in the generation of innovation, which has been studied in different areas of knowledge, with a lot of publications.

It is hoped that the article can contribute in a practical way, supporting researchers involved with the development process of new products. The authors believe that the present paper can help companies and incubators improve processes of R&D of new products, following the best practices of large innovative companies.

Future studies are still needed for the survey of best practices of PDP is enhanced. It is necessary to evaluate the suitability of these practices to small and medium enterprises (SMEs), because the practical questions were analyzed in large companies, which have different characteristics of SMEs and larger structures and more efficient, which facilitates the implementation of these practices. This study also did not address the strategic issue of the innovation process.

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