
Managing new product development process: a proposal of a theoretical model about their dimensions and the dynamics of the process

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Abstract. The development of products consists of a process that involves knowledge and several functional areas and presents a high degree of complexity and iteration in its execution. The literature presents several models and approaches for characterizing the new product development process. However, they usually do not adequately represent its dynamics. The present work aims at characterizing the product development process based on the nature of its elements covered by the literature. A representative conceptual model of this process is proposed within two levels of integration. The theoretical model is based on six dimensions (strategic, organizational, technical, planning, control and operational) integrated in the levels of structural and operational. It also identifies what the elements that compose the operational dimension are and how the interaction between them might be characterized. The paper also emphasizes the need for new studies with a detailed analysis of the interaction and the integration of the elements here presented.

Keywords. Product development management; product design; new product development.

1 Introduction

New product development (NPD) presents several characteristics that differentiate it from other processes, as follows: high degree of uncertainty and risks in the activities; difficulty to change initial decisions; the basic activities follow an iterative cycle; the creation and handling of a high volume of information and multiple requirements to be considered [14]. NPD is defined as the transformation of a market opportunity into a product available for sale [9], through a set of activities [14] executed in a logical way, sequentially or concurrently [6].

Several models were created in the last decades containing rules, guidelines and procedures for managing product development [7]. The models initially described

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the process as a linear system, with discrete and sequential stages, while more recent studies consider that the development process evolves through stages, but with overlap and feedback loops [10].

According to ref. [8], the development projects became a collaborative entrepreneurship with highly complex interdependencies. In doing so, the search for more effective organizational patterns in the development process shall include a detailed analysis of how the development really happens [4].

Considering then the inadequate representativeness and applicability of theoretical models and frameworks to deal with the dynamics of the product development process, this paper aims at characterizing this process through a representation of its dimensions and the elements that compose it, beyond analyzing the interaction between each party.

2 Research Methods and Techniques

This paper can be classified as a theoretical-conceptual research. The development was based on a literature review, in which papers related to management, coordination, integration and decisions in the product development process were gathered. A search in the following journals was initially done from the period of 1999 to 2006: *Journal of Product Innovation Management*, *Management Science*, *Research and Development Management*, *Production and Operations Management* e *Research Policy*. After that, papers were obtained by key words in the following databases: *emeraldinsight*; *extenza-eps*; *blackwell-synergy*; *sciencedirect*. Finally, other papers were selected by cross-reference, adding up to 52 papers in total.

The research can be divided in two main parts. In the first part, several ways of classifying the product development process were conducted. Then, based on the previous analysis, a classification of the dimensions that compose the NPD process was proposed. The topics that compose each dimension were then grouped according to this classification. The second part of the literature review was aimed at identifying the elements that characterize the development process itself and the way they interact. To do this, the papers that have an empirical approach were analyzed considering approaches and tools in which these elements are considered.

3 Literature Background

3.1 Approaches and classifications of the development process

According to ref. [3], the study of NPD management, widely and in an integrated way, is quite new. Since it is a vast knowledge field [3] it can be classified in several ways. In the literature, several approaches were found and there is an overlap of themes in some areas. Product development approaches can be classified according to an academic perspective [3] that includes [9]: marketing, organization, engineering and operations management. Another way of looking at

NPD process is according to the perspective of the functional areas, that conceive NPD in a different way, thus complementary. Other emphases can be found in the product development literature, for example, the use of methods and techniques.

Ref. [3] presented a classification framework of the more relevant topics in product development management. Three dimensions have been proposed: strategic, operational and performance evaluation of the product development. The strategic dimension is divided into two main topics, including subjects related to portfolio management, capacity dimensioning and inter-organizational and inter-functional integration. The operational dimension is divided into the following topics: the development process itself and the use of methods and techniques and the work organization.

Ref. [9] proposes an approach based on the decisions. They affirm that while *how* products are developed differ not only across firms but within the same firm over time, *what* is being decided seems to remain fairly consistent. In this way, they propose a classification that organizes the decisions into two categories: the decisions within the context of a single project and the decisions in setting up a development project. On one hand, the authors in ref. [9] divide the decisions within the context of a single project in four categories: concept development, supply-chain design, product design, and production ramp-up and launch. On the other hand, the decisions in setting up a development project are divided into three categories: product strategy and planning, product development organization, and project management.

Other authors in the product development literature have used the approach based on decision. Ref. [10] considered three levels of NPD decisions: strategic, review and in-stage. The 'strategic' decisions are related to market and product strategies and portfolio management. The decisions in the 'review' level occur between stages, while 'in-stage' decisions refer to those in the operational level of each phase. In the same line of thought, in ref. [1] the decisions are classified in four levels: strategic planning, tactical planning, operational planning and planning infrastructure. The work in ref. [13] stems from ref. [9] and proposes a division into two systems: the operational system and the development system.

From the classifications shown earlier, the strategic and the operational dimensions are explicitly cited in almost all of them [1,3,9,10]. Its concepts are also considered in the classification proposed in ref. [13]. Other dimensions that can also be also highlighted are the organizational and the project management that are cited in almost all classifications.

3.2 Dynamics of the development process - approaches and concepts

The increasing complexity and the cooperative environment in the design process requires a more effective coordination of it [8]. On the other hand, coordination underlies many of the management problems in designing products rapidly and effectively [2]. The most used representations and techniques do not adequately describe the dynamics of the development process [6] and this requires an analysis of how the development really occurs [4]. Considering this, several authors are

working on new approaches and concepts aiming at providing tools that will help in the coordination, integration and in the development process decision making.

Ref. [2] proposed the ‘coordination structure’, an approach to model the organizational situations that considers the concepts of responsibility interdependence, social networks and shared objects. The approach that was proposed, according to the authors, provides the foundation upon which information is communicated and processed.

The work in ref. [6] was based on the Dependency Structure Matrix (DSM), proposed in ref. [16], to deal with the information interdependence among tasks. The proposed approach has the objective of designing project plans that produce greater concurrency and better iteration management, focusing management attention on the essential information transfer requirements of a project.

In doing so, the concepts presented here should be considered, once they affect the way models are developed and applied and the way that the development process works [10]. Ref. [15] states that uncertainty reduction will be facilitated by higher levels of integration across functions and the use of modes of integration that have higher potential for information processing.

4 Proposed Conceptual Model

4.1 Dimensions of the development process

A classification of the dimensions of NPD process is proposed based on the literature review. This classification stems from refs. [3,9]. Therefore, instead of considering an approach based uniquely on the decisions, the nature of the topics that compose each dimension is considered. The resulting classification contains six dimensions, the ones that are predominant in the literature, plus the ones that resulted from the classification based on the nature of the elements. The proposed dimensions are: strategic, organizational, technical, planning, control and operational. The strategic dimension represents the attempt to articulate the market needs, the technological possibilities and the company competencies, in a way that allows the business to perpetuate [3]. Decisions in this dimension are related to market and product strategies and the portfolio management [10]. Some decisions that can be cited as being strategic are: what is the timing of product development projects? [9]. The organizational dimension consists of topics related to the social systems and the environment in which the product development activities are held [9]. A particular aspect of the classification herein proposed is the inclusion of product development models in this dimension, considering that they represent the structure that the product will be developed through. This characterises it primarily as an organizational element, since this dimension contains not only the elements of a unique project, but also what refer to the whole company. Other topics like competence and technology development policies were included in this dimension as well as the integration along the supply-chain. Another dimension that distinguishes this classification from the ones in the literature is the technical dimension. This dimension includes the product development methods and tools.

They are means that exist to support the product development activities [14]. These tools can be fit into any area of the classification proposed by [11]: project techniques, organizational techniques, manufacturing techniques, information technologies and supply-chain. Some of these tools are shown in table 1.

Table 1. Product development dimensions and topics

Strategic	Organizational	Technical	Planning	Control	Operational
			Scope definition		
Portfolio management	Organizational structures	FMEA	Resources and cost planning	Scope verification	Development execution: application of the strategic definitions, in a defined
Market intelligence	New product development models	QFD	Activity definition and duration estimating	Cost control	organizational structure, in accordance with project plans, making use of specific methods and tools.
Platform renewal	Competence development policies	DFMA	Activity sequencing and schedule development	Schedule control	
Capacity dimensionin	Technological development	CAD		Quality control	
Budgeting	Supply-chain integration	CAPP		Project team management	
		CAE		Risk monitoring and control, etc	
		PDM			
		Robust Design			
		Modular Design, etc.			
			Risk identification and analysis, etc.		

Planning and control dimensions are in the context of project management. The classification herein proposed, based on the differentiated nature of its elements, divided the project management techniques in two other sub-dimensions: planning and control. The items presented in table 1 were based on ref. [12]. Finally, the operational dimension does not present specific topics, but consists of the project execution itself. It is about the application of the strategic definitions, in a defined organizational structure, in accordance with project plans, making use of specific methods and tools.

4.2 Decisions and integration levels

The decision levels proposed in this article are based on the two category division proposed by ref. [9]. However, they are distinguished in some aspects. Their classification is based on the decision perspective, that considers *what* is decided in the development process, instead of considering the way the development happens (i.e. *how*). In this sense, the decisions were organized in two categories, as follows: the decision in the context of a single project and the decisions in setting up a development project.

The present work uses both *how* the product is developed as *what* is decided. Therefore, it proposes two levels of integration in the product development process. The first level refers to *how* the product is developed and was herein called the structural level. At this level, the decisions are aimed at setting up the organizational context and they refer to corporative patterns [9]. Thus, the

integration at the structural level corresponds to the definition and the alignment at the company about the standards to be used during the development project.

The second level refers to the application of the organizational standards in a specific project. Therefore, this level contains both the decisions in a single project, like the planning and execution of the development project. The integration at the operational level corresponds to the application of the organizational patterns in the project being developed. In such a way, the development process could be represented, in a macro view, by six dimensions and should be integrated in two levels. At a higher level, there would be the integration in the organizational context. The development would then happen through the integration in the operational level, where the standards would be applied according to the project particularities. The development of the product would be the result of the application of the elements that compose the five dimensions (strategic, organizational, technical, planning and control) at the operational dimension that characterises the operational integration.

Figure 1 illustrates these dimensions and the integration levels mentioned.

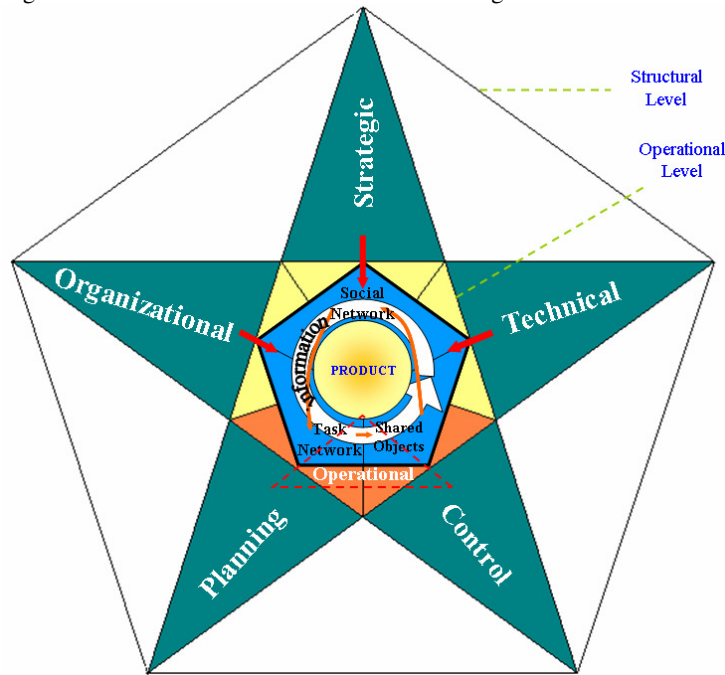


Figure 1. Representation of the conceptual model of the product development process

4.3 The elements and the dynamics of the product development process

Once the product development takes place at the operational dimension, the understanding of how it really happens is of great importance [4]. In this way, it is

necessary to consider the information exchange and issues associated to reworks during the development [4], the changes [2], the overlaps [9], among other things. The current analysis did not consider only approaches or methods that deal only with subjects associated to coordination or the dynamics of the product development process. It aims at identifying and analyzing the elements that compose the operational dimension and that explain the dynamics of the development project and uses the concepts found in the literature review.

Initially, there were identified three basic elements that compose this dimension. Two of them were based on the elements that compose the coordination structure proposed by ref. [9]: the social network and the shared objects network. The third element uses the concepts of the interdependence modelling from ref. [5] that considers the interdependence between tasks and resources.

In this sense, the present work proposes that the operational dimension is composed by the following elements: a social network, a task network and another shared objects. The social network comprises the people or groups participating in the development. The task network includes the activities necessary to develop the product. Now, the shared objects represent the information that are created and transformed during the project as, for example, the customer requirements, the product specifications, the project of the components [2], and so on. In this way, product development occurs through the integration of these three elements: the social network uses the shared object to execute the tasks and doing so, it will generate new shared objects or transform the previous ones. Considering the task of concept development, for example, the social network would use: *customer requirements* (shared objects) to *develop the product concept* (task). So, the generated concept (shared object) will be used by the social network to *develop the product specifications* (tasks), for example.

A fourth element that can be included in the previous representation would be the flow of information within the project. It can be considered as a mean through which the process happens. As can be seen figure 1 shows the conceptual model of the development process with their dimensions, elements and a representation of the dynamics of the operational dimension.

5 Concluding Remarks

Since this study is part of an on-going research and it is not fully completed, conclusions should be taken with care. Nevertheless, some concluding points deserve attention. Firstly, it has been identified in the literature that it seems to exist a lack of a conceptual model that represents all dimensions and interactions in the new product development process. Secondly, the theoretical model shown in this article comes and meets the needs of a more adequate representation that describes the dynamics of the development process pointed out by some authors earlier cited. It integrates different perspectives of new product development process, considering the nature of the elements as the basis for its elaboration. Finally, even as a preliminary study, the conceptual model here proposed seems to contribute to the understanding of the dynamics of the product development process, given the

separation of the operational dimension of the other five that constitute the structure of the development project. This gives a clear notion that, although the methods and techniques that compose each dimension are very well understood, the conjoined application of them in a development project needs to be better detailed and studied.

In this sense, future studies shall be developed considering the points here addressed and a detailed analysis of the conjoined application of the topics that compose each dimension in the operation dimension seems to be also important. In addition, an analysis of how the integration of all these elements occurs, together with methods to optimize it would contribute to the understanding of such a complex process as new product development.

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