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# Analisis of predevelopment models and activities: a systematic bibliografic review

## *Análise dos modelos e atividades do pré-desenvolvimento: revisão bibliográfica sistemática*

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**Abstract:** This paper has as main objective the systematic collection and analysis of models and activities proposed by the literature for the conduct of the pre-development phase of new products, as well as the techniques and tools used for the implementation of this phase. A Systematic Bibliographic Review identified the existence of 10 models composed of different activities for the predevelopment phase. These models were published between 1988 and 2013. They sought to systematize the predevelopment phase and guide managers in its conduct. It was observed that, although with different nomenclatures, activities such as opportunity identification, opportunity selection, idea generation, idea selection, concept development, concept selection, and project planning are recurrent in all models. Therefore, these activities are essential and must be present in the predevelopment phase, regardless of the type of product manufactured or sector to which the company belongs. Also, 57 different techniques aided by various tools were identified. According to the authors, these techniques can be effective in the conduct of predevelopment activities.

**Keywords:** BSR; Predevelopment models; Activities and techniques.

**Resumo:** *Este trabalho tem como objetivo o levantamento sistemático e análise dos modelos e atividades propostos pela literatura para a condução da fase de pré-desenvolvimento de novos produtos, bem como das técnicas e ferramentas adotadas na fase. A Revisão Bibliográfica Sistemática realizada identificou a existência de 10 modelos compostos por diferentes atividades para a fase do pré-desenvolvimento. Estes modelos foram publicados entre 1988 e 2013 e buscam sistematizar o pré-desenvolvimento e orientar os gestores na condução da fase. Observou-se que, embora com nomenclaturas diferentes, atividades como identificação de oportunidades, seleção de oportunidades, geração de ideias, seleção de ideias, desenvolvimento de conceitos, seleção de conceitos e planejamento do projeto, são recorrentes em todos os modelos, concluindo-se, portanto, que estas são essenciais e devem estar presentes na fase de pré-desenvolvimento, independentemente do tipo de produto fabricado ou setor no qual a empresa atua. Também foram identificadas 57 diferentes técnicas, auxiliadas por diversas ferramentas que, segundo os autores, podem ser eficazes para a condução das atividades de pré-desenvolvimento.*

**Palavras-chave:** *RBS; Modelos de pré-desenvolvimento; Atividades e técnicas.*

## 1 Introduction

The pre-development term refers to the translation of the English terms "The Fuzzy Front End" or "fron End" used for the first time in the article "The strategist's role in shortening product development" from Smith and Reinertsen in 1991 and corresponds the activities and the period between the generation of an initial idea for a new product and the company's decision to invest in its development (Smith & Reinertsen, 1991).

The development of new products is an important strategy for companies introduce innovations into the market and the initial stages of this process are critical to the proper definition of the innovations that the new product, or an improved product, should present in the market, and that will actually be developed in the following stages of the development process. The pre-development constitutes therefore, in the initial phase of the new product development process or PDP, and is therefore directly related to the strategies and innovative capacity of companies.

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According to Koen et al. (2001) The basis for the successful development of new products is based on the pre-development stage. This phase involves the identification and selection activities opportunities, generating ideas and concepts and evaluation of concepts of products (Crawford & Benedetto, 2006). Throughout these activities, there is a dynamic and complex flow of information on business strategies, requirements and market trends, technological alternatives and resource allocation. At this stage important decisions are made, because that is where top management of companies evaluates the strategic and financial attractiveness of the project, and whether these adequately complement the current product portfolio. Thus, bad decisions at this stage may result in failures in the performance and results of the new product (Mendes & Toledo, 2012).

The consequences of errors committed in the pre-development phase can be disastrous and have caused problems for large companies considered high performance and well structured, for example, Xerox (Chesbrough, 2003).

As a result of this alert, there has been publications that seek to guide companies in carrying out the pre-development activities. Among the publications are highlighted further in this article, the works of Clark & Wheelwright (1993), Cooper (2001), Koen et al. (2002), Crawford & Benedetto (2006), Reid & Brentani (2010, 2012), Florén & Frishammar (2013).

However, according to Florén & Frishammar (2013), although studies on the pre-development have evolved in recent years, they are still incomplete and does not help effectively in their practical application in companies, it is still unclear what activities must be performed at this stage, how to perform them and control them and what key results are expected from pre-development.

This paper has as main objective the systematic collection and analysis of models and activities proposed by the literature for the conduct of pre-development phase, as well as the techniques and tools used for the implementation of this phase.

The next section presents a systematic literature review of methodology used to survey the state of the art models, techniques and pre-development tools.

## 2 Method

The main technical procedure used for the research, identification and analysis of the models, techniques and pre-development tools is the Bibliographic Systematic Review (BSR), a methodology of specific research, formally developed for assessment and evaluation of data pertaining to a particular research topic. The systematic review model used in this study consists of three phases: planning, execution and analysis of results (Biolchini et al., 2005). The planning phase consists in defining the review objectives and its protocol and this protocol is composed by three sub-phases: review planning, problem formulation, and data collection and evaluation.

The implementation phase involves the initial identification studies, selection and evaluation according to the criteria of inclusion and exclusion set out in the review protocol established in the planning phase. After the selection of the studies in the analysis of the results phase, the study data are extracted (Biolchini et al., 2005). To assist in the systematic literature review were made compilations in a database containing titles, keywords, authors and dates of publications.

## 3 Bibliographic systematic review: models and predevelopment activities

This section is composed by the description of the way in which the systematic literature review was conducted and the results obtained by following the stages of planning, execution and analysis of results.

### 3.1 Phase I: Review planning

According Brereton et al. (2007) in the planning stage should be formulated questions that will guide the validation of the protocol review. Its purpose is to identify published works on the activities developed in the early stages of the product development process. For this purpose it has been prepared the research protocol containing:

#### 3.1.1 Problem formmulation

The main objective of the review was to run survey studies that addressed in general, the main models of pre-development, activities, technical and pre-development tools. Therefore the initial questions were: What are the existing models in the literature addressing the management of the new products pre-development? What activities compose the pre-development? What techniques and tools can be used to operationalize the pre-development?

#### 3.1.2 Data collection and evaluation

According to that defined in the previous phase, the databases were identified (*Science Direct*, *Emerald*, *SciELO and Wiley*) and the keywords and / or research expressions to be used in conducting the review. These databases were chosen because they contain more works related to the topics studied and because they are more related to production engineering, management and administration. It was observed

that some authors, although referring as the product pre-development stage, they adopted terms such as *front end of innovation*, *the front end of new product development*. These expressions were then included in the research terms, as Chart 1 shows.

Following similar claim brought by Biolchini et al. (2005) and Pigosso & Rozenfeld (2011), logical expressions have been used to combine the keywords and their synonyms for best results, including, *models*, *tools*, *practices*, *techniques* (models, tools, practices and techniques). During the research new keywords have arisen because the pre-development activities envolve marketing areas, product development, quality management and among others, which makes it fairly complex and dynamic. This planning stage have been found 832 works containing the terms or part of the terms *fuzzy front end*, *front-end*, *pre development* or *pre-development* in titles or abstracts. For the inclusion or exclusion of the articles were first evaluated the titles and abstracts. Those who were not related to product development or the pre - development were excluded. Thus, articles 352 papers were initially excluded. Of these, 88 were not related to product pre - development and they were raised by the seeking in the title part of the expressions used in the researches as "*fuzzy, front, development*". The other 264 just mentioned the product pre - development in a superficial manner, with emphasis on the development stage and not addressing specific pre-development practices. After the first filter 480 works remained.

### 3.1.3 Analysis and interpretation of data

Once the publications were selected, this stage involved the extraction of relevant and pertinent data for the purpose of systematic review and data representation standards were used in the evaluation protocol and the criteria for the classification (Biolchini et al., 2005). To facilitate the search of the selected studies it was created a sheet containing: work title, keywords, year of publication and author's name. This procedure allowed the identification and exclusion of duplicated papers, thus, they were available in different databases, such as SciELO and Emerald.

## 3.2 Phase II: Implementation

In this second phase were evaluated in the remaining 480 articles, abstracts that include the established terms. After reading these abstracts 225 works were excluded among chapters of books, papers, theses or dissertations that contemplated the product development process as a whole and not focused in the initial stages. Subsequently, were performed two more filters analyzing the introduction and closing remarks, being excluded respectively over 132 and 55 works.

After this process were finally selected 68 works. The analysis of these selected works indicated the need for reading new works that do not specifically were about the product pre - development, but activities carried out in these phases and as well as more details on the techniques and the tools used to operationalize such activities. This way new search mode was performed and reaching over 61 works, however, due to size limitations and rules in the magazine will not be detailed here, but the same procedures BSR have been followed. Since then, were selected and analyzed 129 works including books, papers, dissertations and theses related to pre-development and activities in the pre-development phase.

## 3.3 Phase III: Analysis of the results of BSR

The identified papers (129) are distribuited in this manner: 74 are articles published in *journals* or scientific journals, 40 are among books or book chapters, 6 are papers published in national and international conferences, 5 are national and international PhD Thesis, 2 are papers published in specialized websites and 2 dissertations.

**Chart 1.** Terms adopted for the pre- development.

| Terms Adopted | Authors |
|---|---|
| Fuzzy Front End/ Front End | Khurana & Rosenthal (1997); Kim & Wilemon (2002); Alam (2003); Reid & Brentani (2004, 2010); Frishammar et al. (2011, 2012); Kurkkio (2011); Reid & Brentani (2012); Florén & Frishammar (2013). |
| Front End of Innovation | Koen et al. (2001, 2002); Poskela & Martinsuo (2009); Poskela & Martinsuo (2009); Teza (2012). |
| Front End of New Product Development | Oliveira & Rozenfeld (2011). |
| Pre-development/pré-desenvolvimento | Cooper (1988); Mendes & Toledo (2012); Costa & Toledo (2013, 2015). |

Source: The author.

Figure 1 shows the evolution of the pre-development related publications in the period from 1984 to 2013. This period comprises 29 years, however in only 25 publications were identified. Considering 29 years, the average of publications per year is of 4.45. Considering the years in which there was effectively publications the average is of 5.16. The peaks of publications occurred in the years of 98, 2001, 2002, 2006, 2012.

As shown in Figure 2, based on the average of publications (only in years in which there were publications) in the decades: from 1980 to 1989

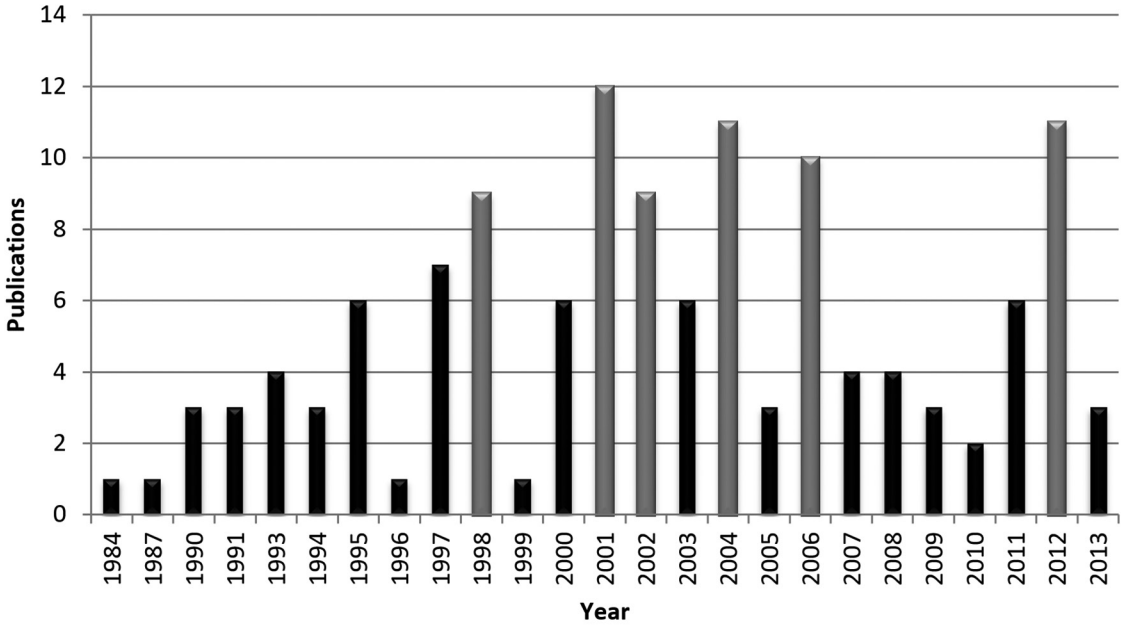


**Figure 1.** Amount publications per year.

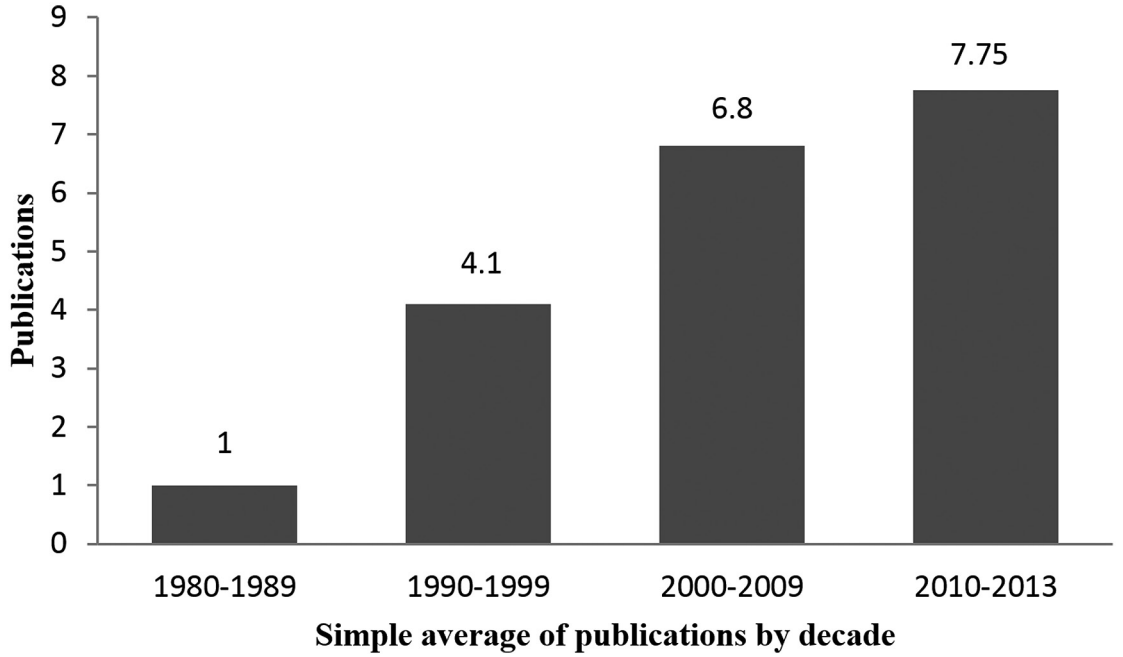


**Figure 2.** Simple average of publications by decade.

(with the exception that in this decade publications occurred only between 1884 e1987); 2000-2009; and 2010-2013, the averages are respectively of: 1.0; 4.1; 6.8, 7.75, indicating upward trend in the number of publications.

This increase may reflect the growing importance of issues such as innovation for companies. The pre-development phase is directly linked to the discoveries issues, creativity and feasibility (technical, commercial, financial) and therefore, arouses the interest of both companies as researchers, since the proper management of their activities may influence the success of new products and reduce development costs.

As shown in Figure 3, Robert G. Cooper is the author with the most number of publications on the subject, for the period corresponding to the 1984 2013. For best visualization of this evolution, the decades were analyzed until the year 2013. The Cooper works in addition to defining a set of activities for pre-development, also suggest techniques to assist in performing these activities, such as *brainstorming,* interviews with employees and customers, leading users, and feasibility analysis in all activities, from identifying opportunities to concept test.

The journals that most published on the subject were: *Journal of Product Innovation Management*, *Research Technology Management and R & D Management*, see Figure 4. However, were found in smaller amounts publications in several other journals.

It has been found in studies that there are 10 different models for pre-development proposed by the authors cited in Chart 2. These models will be discussed in section 3.3.1. Noting, however, the country of origin of the models and more specifically of the authors who developed the patterns analyzed, as can be seen in Chart 2, there is a U.S. predominance, however, as the topic is current, emerging and it has been significant for companies and researchers, it is possible to observe researches also focused on pre-development in Canada and Europe.

### 3.3.1 Analysis of selected publications

After reading the selected Works it was verified the existence of 10 models that suggests ways considered effective for management of pre-development activities. These models have been proposed by the authors: Cooper (1988), Murphy & Kumar (1997), Khurana & Rosenthal (1998), Koen et al. (2001), Flynn et al. (2003), Boeddrich (2004), Reid & Brentani (2004, 2012), Whitney (2007), Brem & Voigt (2009) Kurkkio (2011) and suggest activities that orientate the phase conduction, as this is considered complex and difficult to systematize by the companies, as well as to list tools in the literature or practice of the companies that can assist in carrying out the activities.

Cooper (1988) proposed a model consisted of three stages: Stage I involves activities of generating and screening ideas. Stage II involves the preliminary analysis of market activities. The Stage III begins with

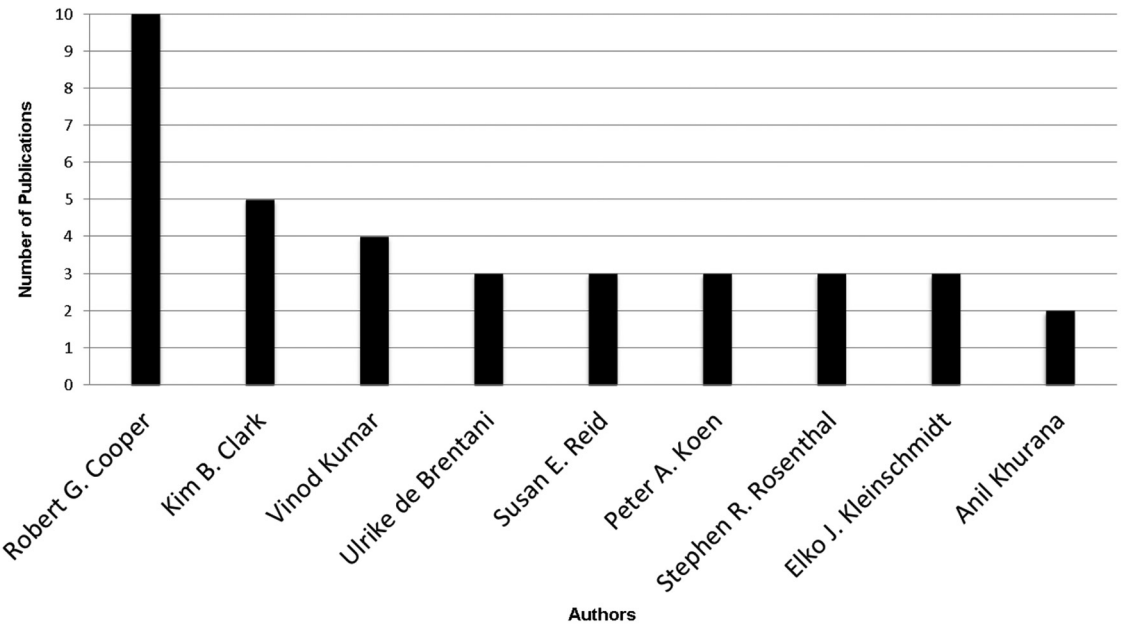


**Figure 3.** Publications by authors in the period considered (1984-2013).

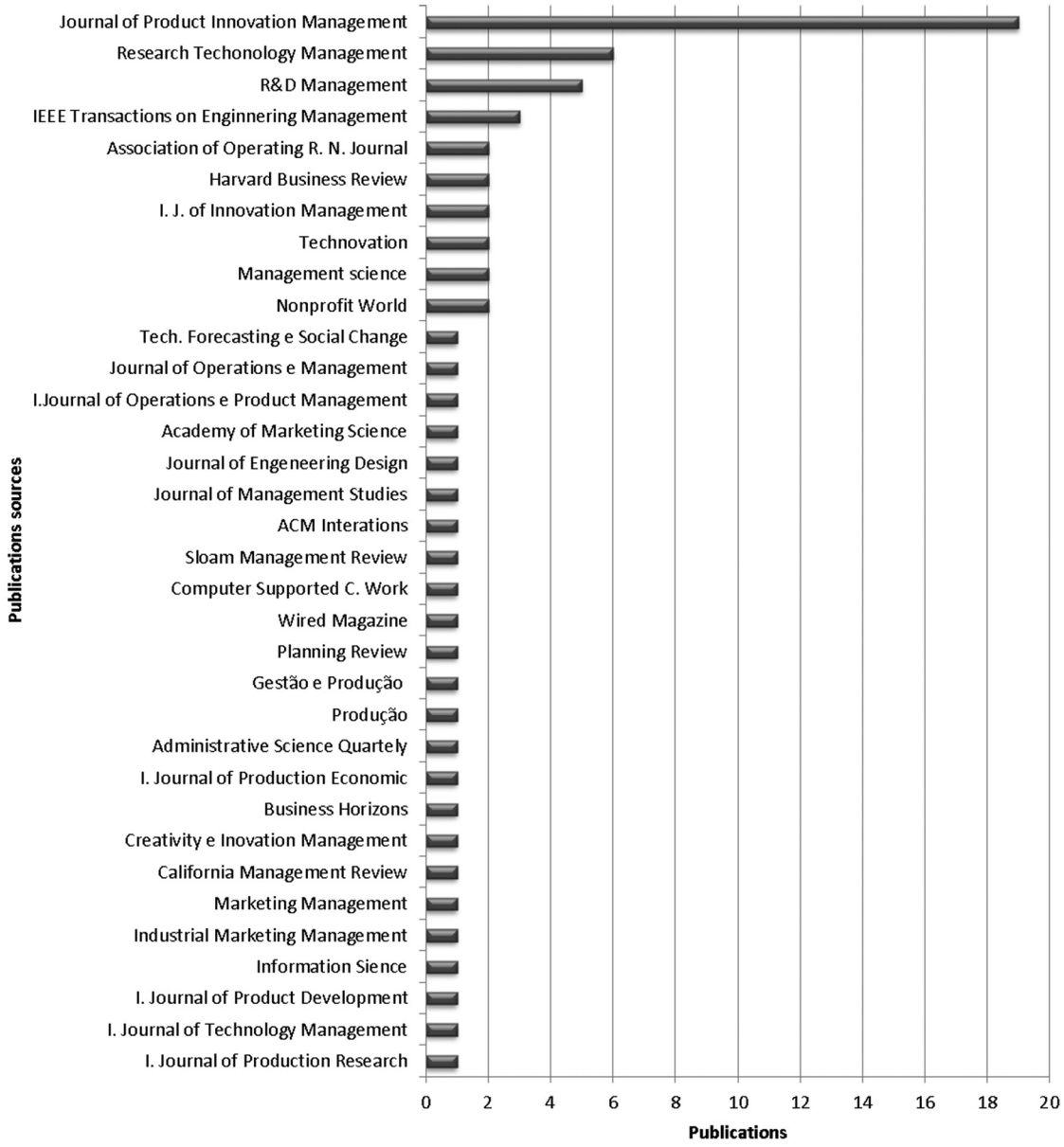


**Figure 4.** Publications for journals.

the activity of identification concept, and it ends with the assessment of the key concept for the decision whether to continue the project. Murphy & Kumar (1997) proposed a model for the pre-development divided into three stages: idea generation, product definition and project analysis. The model was constructed from data obtained by the authors, through a survey of 53 employees among production managers, marketing and product engineering from 15 leading technology companies, integrated circuit board producers in Ontario, Canada.

In the model of Khurana & Rosenthal (1998) pre - development consists of three phases: "Pre-Phase Zero," where opportunities are identified and ideas generated, based on technical analysis and market developments; "Phase Zero", wherein the product concept is elaborated and "Phase One" in which the technical and market feasibility is evaluated, in addition to being made project planning.

The model Koen et al. (2001) is the result of a survey conducted by the Industrial Research Institute (IRT), Texas (USA), together with eight companies (Air Products, Akzo Nobel, BOC, DuPont, Exxon, Henkel, Mobil and Uniroyal Chemical) in order to consolidate a list of best practices to be held in the early stages of the product development process by

**Chart 2.** Origin of the analyzed studies.

| Author | Institution | Country |
|---|---|---|
| Cooper (1988) | Harvard Business School | U.S |
| Murphy & Kumar (1997) | Charleton University | Canada |
| Khurana & Rosenthal (1998) | Boston University | U.S |
| Koen et al. (2001) | Stevens Institute of Technology | U.S |
| Flynn et al. (2003) | National University of Ireland/ University of Dundee | Ireland<br>Scotland |
| Boeddrich (2004) | Wilhelm Büchner Hochschule | Germany |
| Reid & Brentani (2004, 2012) | Bishop`s University<br>Concordia University | U.S<br>Canada |
| Whitney (2007) | Aerojet Technology Council | U.S |
| Brem & Voigt (2009) | Friedrich-Alexander University of Erlangen-Nuremberg | Germany |
| Kurkkio (2011) | Lulea University of Technology | Sweden |

Source: The author.

providing a common language and a set of planning innovation activities. It was developed from the need identified by the authors to provide greater clarity to the pre-development. It consists of three dimensions: the first covers the aspects of leadership, culture and business strategy. The business strategy drives the other key phases. The second considers the stages of pre-development: identifying opportunities to the concept definition. The third dimension comprises the influencing factors in the pre-development performance (organizational capabilities, factors external to the company, technological innovation etc.), under which the companies do not have full control.

Whereas the growth capacity of an organization depends on its ability to generate and explore new ideas for their own benefit and long-term, Flynn et al. (2003) proposed a model divided into 4 phases: strategic direction; environmental scanning; identifying opportunities and generating ideas or management. The strategic direction phase defines the guidelines and general strategies of the organization. The environmental scanning phase involves researching and monitoring the internal and external environment to start generating ideas, resembling goals in the stages of idea generation of previous models. The output of this phase is a portfolio of potential opportunities that can be developed and analyzed to development in the next phase, the generation of ideas. In the phase of idea generation, the development of the stimulus or initial idea (proposed in the previous phase of identifying opportunities) in a more specific concept, recognizable to be explored in more detail (Flynn et al., 2003).

Also focused on generating ideas during the pre-development, Boeddrich (2004) presents a model that separates the processes to be performed on one side (strategic guidelines, generation and ideas adoption, screening of ideas and development of new concepts of products) and the organization's responsibilities associated with the other activities (development of guidelines by senior management and development management, strategic analysis of ideas and choice and decision of the best ideas by the cross-functional team). Reid & Brentani (2004) proposed a theoretical model for the management of pre-development phase of new products considered as radical innovation, based on the flow of information and decision-making. The model consists of interfaces: - i) *boundary interface; ii) gatekeeping interface); iii) project interface* that occur during the pre-development and are critical to decision making, since the information flow from the environment to the organization and the organization to key individuals responsible for the creation of a new process of ideas and products.

Whitney's model, (Whitney, 2007), is composed of three interfaces represented by: input, output, and system environment. The entry are factors that stimulate the process as new business goals, customer needs and new insights etc. The system environment (considered by other authors as activities) consists of 5 elements: identifying and selecting opportunities; generation and selection of ideas; research and development; concept synthesis; analysis and control. The output is a concept in the synthesis ready for the development itself. Established the framework for the pre-development, Whitney (2007) focuses attention on the mechanisms (tools and techniques) used to operationalize the process.

Brem & Voigt (2009), developed a model based on the tunnel of ideas for the development of products proposed by Deschamps et al. (1995), however, other elements were added to the initial model including a bank to save ideas that were not appropriate at the moment, but that could be used in the future.

The funnel-shaped model begins with the stage of collecting and creating ideas, which develops according to the level of creativity and innovative culture of the organization.

The created and collected ideas are compared to those in the database of ideas. Later, these ideas go through the first review, where some may be rejected and postponed other then being stored in the bank of ideas for future contributions. The ideas that are still in the process are classified and enriched, then by passing a new revision, where more ideas may be rejected or delayed. After this process the ideas are prepared for implementation.

Finally, the model Kurkkio et al. (2011) is the latest found through systematic bibliographic review and focuses on innovations in processes rather than products. It is the result of a multiple case study conducted through 28 interviews and semi-structured in four companies being them two metallurgical and two mining. The model has four stages: informal start-up; formal study of ideas; formal pre-study; formal pre-project. For each of the phases activities have been identified. The generation of ideas and discussion of ideas for innovation start at start-up phase. This phase is often unclear and informal. Many ideas may originate from senior management suggestions, or conversations between managers and co-workers in informal situations. In the next phase, formal idea study, a little idea is specified and a clearer conception of the problem is defined. The result of this phase serves as input for the pre-formal study. In this phase the solution begins to be considered in the implementation point of view and is characterized by conducting empirical tests to the solution. The formal pre-project is where are carried out large-scale experiments and feasibility analyzes (Kurkkio et al., 2011). It is possible to perceive that although proposed by different authors at different times, these models have similarities and are in some cases changes from previous models. Whitney model (2007), for example, is strongly influenced by the work of Koen et al. (2001), especially regarding the consideration of "influencing factors" in the pre-development performance, on which companies do not have full control. Whitney model is also presented in a circular format comprises three main interfaces that resemble the three-dimensional model of Koen et al. (2001).

The Voigt and Brem model (2009) resembles in theoretical contribution to the Cooper (1988) and the Koen et al. (2001). For being the latest model Brem & Voigt (2009) adds aspects not covered in the reference work (Cooper, 1988), for example, the study of market dynamics and technology.

Models of Murphy & Kumar (1997) and Khurana & Rosenthal (1998) are clearly based on the model of Cooper (1988), resembling the activities and information flow. The Cooper models (1988), Murphy & Kumar (1997) and Boeddrich (2004) gives the impression of linearity, i.e., the pre-development activities occur in defined time sequence, not being explicitly the effect of feedback or feedback that occur in the process.

As to the models Khurana & Rosenthal (1998), Koen et al. (2001), Flynn et al. (2003), Whitney (2007), Reid & Brentani (2004), Brem & Voigt (2009) and Kurkkio (2011) suggest the existence of interaction between the activities and among those involved in the pre-development.

As shown in Chart 3, most models emphasizes the pre-development of new products with the exception of Whitney models (2007) and Brem & Voigt (2009) that deal with the development of new technologies that support new products.

Because of the complexity of the pre-development phase the described models suggest, in some way, means to become their management more efficient and effective, either through the establishment of activities, organization, development of common nomenclature, establishing tools, gathering management information for the stage or the listing of best practices.

However, it is observed in all the models some limitation concerning to its applicability, as shown in Chart 3. These limitations are not exhibited by the authors of the works giving the idea that the models are generic and applicable to any kind of company.

Only the works of Brem & Voigt (2009) and Kurkkio (2011) mention the impossibility of generalization because they are models developed having as object of study very specific sector companies, such as technology and metallurgy respectively. It is importante to highlight that the models presented are based on literature reviews or developed through case study. Those derived from literature reviews are based on the best practices cited in the literature and therefore they do not present the results of its practical application, but only cite the benefits that can be expected from its application.

The models developed from review and case study were not practiced in the surveyed companies, ie companies were used only as a source of information for its elaboration and again the authors only cite the expected benefits from the adoption of these models. Thus, it is not possible to identify and analyze the actual effectiveness of the models proposed by the authors.

### 3.3.2 Correspondence between the activities of pre-development models

The number of stages or phases in those models does not vary much from one to another (Chart 4), however it is known that for each activity there is a

**Chart 3.** Comparison of the models for pre-development.

| Author | Emphasis | Number of steps | Goals | Limitations |
|---|---|---|---|---|
| Cooper (1988) | Consumer goods | 4 | Propose model that helps in better management of the initial PDP activities aimed at reducing failures in new products development. | Requires relatively large time, money and people with specific skills. |
| Murphy & Kumar (1997) | Capital goods | 3 | Gather and provide information to companies working on the steps and activities undertaken prior to the development of the product. | The model was developed considering observations in a small sample of companies. |
| Khurana & Rosenthal (1998) | Consumer goods and Capital goods | 3 | List activities, problems and success factors in the pre-development | Few details on how to operationalize the activities. |
| Koen et al. (2001) | Consumer goods and Capital goods | 5 | Consolidate best practices and establish a common language for the activities of pre-development. | Few details on how to operationalize the activities. |
| Flynn et al. (2003) | Consumer goods and Capital goods | 4 | Propose a model for improving the ability to "ideas management" for new products with support to computational tool. | It takes time, resources and skills. It depends on team cooperation. |
| Boeddrich (2004) | Consumer goods | 4 | Propose systematization of part of the pre-development. It also lists requirements for an efficient flow of ideas in the pre-development. | Absence of details on the practical implementation of the model. |
| Whitney (2007) | Technology | 5 | Establishes activities for the pre-development and list tools to operationalize these activities. | It does not address or show practical outcomes or benefits of adopting the suggested tools. |
| Reid & Brentani (2004, 2012) | Consumer goods and Capital goods | 3 | Propose a model for management of the pre-development radical products, based on the flow of information and in the decision making. | Strictly theoretical. Does not have practical results. |
| Brem & Voigt (2009) | Software and Information Technology | 3 | Model with pre-development bank for storage ideas. | Based on a single case, precluding generalization. |
| Kurkkio (2011) | Capital goods | 4 | Propose a model for development processes. | The model was developed from a field research in metallurgical and mining industries, making it difficult to generalize their application. Focus in the continuous processes. |

set of other necessary sub-activities for its realization. The complexity and the number of these sub-activities may be significantly different depending on the kind of project that is being developed, the urgency of the project, the company's objectives among others.

However, some activities appear recurrent in all models, as Chart 4 shows.

Although occur at different times, the phases (1) and (2) the models of Cooper (1988); Murphy & Kumar (1997); Khurana & Rosenthal (1998); Brem & Voigt (2009); Kurkkio (2011), Boeddrich (2004); (2) Whitney (2007), (3) Koen et al. (2002) and (3) and (4) Flynn et al. (2003) represent the moment in which ideas should be generated, refined, selected and improved. In the model of Reid & Brentani (2004, 2012) ideas are built along its three interfaces.

Other activities present in almost all models are: the identification, analysis and opportunities selection, or verification by techniques and tools to support management of internal or external factors to the company and may result in amelioration or creation of a new product. These activities can be

**Chart 4.** Comparison of activities / sub-phases of the pre-development of the models analyzed.

| **Cooper (1988)** | **Murphy & Kumar (1997)** | **Khurana & Rosenthal (1998)** | **Koen et al. (2002)** | **Flynn et al. (2003)** | **Boeddrich (2004)** | **Whitney (2007) Interfaces** | **Reid & Brentani (2004) Interfaces** | **Brem & Voigt (2009)** | **Kurkkio (2011)** |
|---|---|---|---|---|---|---|---|---|---|
| Ideas generation (1) | Ideas generation (1) | Pre-phase zero (1) | Opportunities Identification (1) | Strategic direction (1) | Strategic direction for innovation (1) | Opportunities identification and selection (1) | Boundary interface (1) | Pre-development (1) | Informal startup (1) |
| Preliminary evaluation (2) | Product definition (2) | Phase Zero (2) | Opportunity Analysis (2) | Environmental scanning (2) | Generation and adoption of ideas (2) | Generation and selection of ideas (2) | Gatekeeping interface (2) | Ideas bank (2) | Formal study of ideas (2) |
| Concept definition (3) | Project analysis (3) | Phase one (3) | Ideas generation (3) | Opportunities Identification (3) | Execution and screening ideas and development concept (3) | Research and Development (3) | Project interface (3) | Implementation (3) | Formal pre-study (3) |
| Development (4) | | | Selection of ideas (4) | Ideas generation (4) | Preliminary design (4) | Concept Summary (4) | | | Formal pre-project (4) |
| | | | Concept Development (5) | | | Analysis and control (5) | | | |

Source: The author.

seen in (1) and (2) from Cooper (1988); Murphy & Kumar (1997); Raid & Brentani of (2004/2012), step (1) and (4) Koen et al (2002), (1) Khurana & Rosenthal (1998); Whitney (2007), (2) Kurkkio (2011), and (3) Flynn et al. (2003). The model of Boeddrich (2004) does not identify when to take place the identification of opportunities, but cites the need for innovative companies analyze the opportunities contained in the generated ideas, however abstract they may be, if well used may result in successful projects. The model of Brem & Voigt (2009) is also not clear as to the identification of opportunities, on the other hand, analyzing more carefully it can be seen that the activities of stage (1) refer the possibilities of identifying opportunities through the creativity and the company's innovation culture.

All authors mention the need for financial and commercial viability analysis, and analyzing the organizational capacity and alignment between the new product and the company's strategy. Yet, not all models bring this account explicitly in the form of stages or phases. It is more evident in the models of Cooper (1988), Khurana & Rosenthal (1998), Koen et al. (2001), Flynn et al. (2003).

From the ten cited models, seven mention the definition and concept test as an important activity for the pre-development. This can be seen in stages (3) from Cooper (1988) & Boeddrich (2004), (2) Murphy & Kumar (1997) and Khurana & Rosenthal (1998), (4) Whitney (2007), (5) Koen et al. (2002) and in stages (2), (3) and (4) Kurkkio (2011). The models of Flynn et al. (2003) and of Brem & Voigt (2009) comprise only the management of ideas, not applying, therefore, the concept definition. The model of Reid & Brentani (2004, 2012) focuses on the flow of information and decision making, not directly addressing the concept definition. However, it is important to consider that the management of information flow and decision-making in pre-development guides the definition of new concepts.

From this analysis it was observed that regardless of the type, the emphasis, the number of stages or runtime major pre-development components activities can be grouped into: identification of opportunities; opportunities selection; idea generation or ideation; selection of ideas; concept development; concepts selections and project planning. These activities, even with different names, are present in all models.

Performing these activities requires a set of techniques or tools that can operationalize them and make the pre-development more efficient and effective.

Chart 5 shows the list of techniques and tools cited in the analyzed models and, according to the authors, can be adopted for the implementation of the pre-development activities.

According to Project Management Body of Knowledge (PMI, 2008), technique is a systematic procedure used to perform an activity to produce a product or result or provide a service, and may employ one or more tools for its execution. Since tool is defined as a template or a software program used in performing an activity to produce a product or a result.

It is noteworthy, however, that frame neither intends to group different nature techniques and nor limit the operation of the activities only to these techniques.

## 4 Final considerations

The analysis of the Works collected by BSR showed that pre-development is not a well established theme indicating, therefore, the need and possibility of various related studies.

It was observed the presence of 10 different models for the stage of pre-development. These models were published between 1988 and 2013 and seek, where possible, organize the pre-development and guide managers in conducting phase.

It is important to note that each model analyzed has a different purpose and proposes solutions for the pre-development companies belonging to different sectors, but all were, somehow, developed based on the pioneering work of Cooper published in 1988. While these models refer to the work of Cooper (1988), they diverge from each other in several aspects. Each model is composed of a number of different activities and each author presents a diverse set of techniques and tools to assist in the implementation of these activities.

It was observed that some activities are recurring in all the models. Such activities, in some cases are given different names, but basically refers to activities of identification of opportunities; opportunities selection; idea generation; selection of ideas; concept development; concepts selection and project planning.

We conclude, therefore, based on the bibliographic review, these activities are essential and must be present in the pre-development phase, regardless of the kind of product or industry in which the company operates.

Were also identified, as shown in Chart 5, 57 different techniques, according to the authors, may be effective for the conduction of the pre-development activities. According to the authors the same technique can be adopted in different activities of the pre-development to achieve different goals, nonetheless, it was not mentioned in the Works any reference indicating the real effectiveness of the application of such techniques. It was also observed that the analyzed models do not mention the practical results of their application, setting up a limitation to this research and reinforcing the

**Chart 5.** Techniques and tools for pre-development.

| Activities | Techniques | Tools | Authors |
|---|---|---|---|
| **Opportunities identification** | Market research; direct contact with consumers; systematic collection of market information. | Spreadsheets, visual panels. | Cooper (1988) |
| | Formal techniques (techniques of creativity, problem-solving techniques, brainstorming); Informal techniques (discussions in cyberspace, ad hoc sections, individual perceptions). | Fishbone; mental maps; mapping process. | Koen et al. (2002) |
| | Environmental factors / benchmarking; insights of employees; creativity techniques. | Mental maps; software for cross-checking. | Flynn et al. (2003) |
| | Market research; analysis of market segments; technological forecasting (trend analysis); trend analysis of consumers, consumers' assessment; scenario planning; tecnology roadmapping; SWOT analysis; Relevance tree, implications wheel. | Software; spreadsheets; graphics | Whitney (2007) |
| **Opportunities selection** | Focus groups; market research; technical "what-if"; competitive intelligence; trend analysis. | Fishbone; mental maps; mapping process. | Koen et al. (2002) |
| | Peer review; Scoring review; economic models; decision analysis; interactive methods; artificial intelligence; portfolio optimization. | Software mathematical programming (optimization and simulation). | Whitney (2007) |
| **Ideas generation** | Environmental analysis techniques; techniques to encourage and sustain a culture of innovation (brainstorming, technology foresight, creativity stimulation techniques). | Partnerships | Murphy & Kumar (1997) |
| | Focus groups; interviews with leading users; brainstorming; periodic review of customer needs; sales force information. | Visual panels | Cooper (1988) |
| | Direct contacts with consumers and users; linkages with other cross-functional teams; collaboration with other organizations and institutions; brainstorming; ethnography. | Idea Bank; spreadsheets, software, information and communication system. | Koen et al. (2002) |
| | SWOT analysis; 5 forces Porter; insight of employees. | Spreadsheets to sort ideas in order of importance. | Flynn et al. (2003) |
| | Ethnographic approaches; lead user; voice technology; TRIZ; ideas management; brainstorming; design of experiments; mathematical optimization techniques; technology point of viability. | Panels; Frames; software | Whitney (2007) |
| **Selection of ideas** | Techniques of technical success probability; probability of commercial success; reward; strategic fit; strategic leverage); formal process of selection of ideas with quick feedback to suppliers of ideas. | Software | Koen et al. (2002) |
| | Peer review; by scores; mathematical programming (optimization and simulation); economic models; decision analysis; interactive methods; artificial intelligence; optimization portfolio. | Software; spreadsheets; graphics | Whitney (2007) |
| **Concept Development** | Technical and design of experiments; Techniques of mathematical optimization; brainstorming. | Software | Whitney (2007) |
| **Concept selection** | SWOT analysis; brainstorming, concept testing; decision matrix. | Software; planning programs and viability analysis. | Whitney (2007); Cooper (1988) |
| **Project planning** | Techniques for planning and conducting the project; scenario planning; simulation; technical and financial analysis. | Software; planning programs and viability analysis. | Whitney (2007); Cooper (1988) |

Source: The author.

idea that, although currently there is greater interest on the topic, studies on pre- development are still in the majority, literature reviews needing, therefore, better targeting, application and research in real cases. Thus, it is recommended to perform works focused on the practical implementation of the designs, allowing potential feedback from application cases.

It is suggested for future works, in-depth analysis of the relationship between the adoption of specific activities and techniques and tools in the pre-development activities, the effectiveness and efficiency of the stage and the PDP's success as a whole. It also suggests it is a detailed study of the degree of influence and contingency of internal and external factors of the organization, that according to publications, are conditions of the pre-development format.

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