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Classification and Use of Methods and Tools in New Product Development

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Abstract. The new product development (NPD) is considered an important business process to determine the competitive advantage of companies. In order to launch products successfully, methods and tools have been applied by companies for improving and supporting the activities performed in that process. However, a comprehensive and integrative classification of new product development methods and tools is not clear. Beyond that, regarding how useful the practitioners consider the methods and tools, the adoption, diffusion and application dimensions of them are still research challenges. To address these issues, the aim of this research is to present a classification of methods and tools, besides to present which of them are really applied and useful in new product development of companies. The novelty of this proposal involves the practical perspective encompassing the practitioner's point of view, which goes beyond the theoretical perspective. Methods and tools identified by means of literature review were classified using a qualitative approach. The classification was validated by practitioners of ten companies specialized in product development. Key findings of the classification proposed are presented based on the following categories: performance objective related, added value, complexity and implementation cost. Finally, the research provides an overview of the usefulness and attractiveness of methods and tools. It can support a valuable guidance for companies in order to improve the use of the most useful ones.

Keywords. New product development, methods, tools, classification, application

Introduction

The new product development (NPD) has been recognized as one of the most critical processes of companies in today's competitive business environment [1],[2],[3]. Therefore, manufacturing companies are challenged to improve their NPD [4],[5],[6], once they are operating in markets that demands innovation, shorter time-to-market, product diversity and higher quality product. In order to achieve a better performance, Rossi et al. [7] claim that companies can apply a set of practices, which encompass methods and tools that lead to the development and launch of new products [3],[8],[9]. Methods and tools can support the NPD activities and the appropriate adoption of them are essential for achieving satisfactory results [6],[9],[10].

Although some authors have studied the positive impact of NPD methods and tools [4], there are still some research challenges on the NPD literature [11]. The application of them, regarding the adoption and diffusion among a group of organizations, is not

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systematized [4],[6],[11],[12],[13] – i.e. the literature is sparse in examining the implementation of methods and tools in manufacturing companies that develop products. Furthermore, there are some studies that do not consider the usefulness of methods and tools under the context of NPD [11]. Concerning the practical application, the companies should understand if they are applying the appropriate methods and tools based on real situation of their NPD [6]. Additionally, some factors may influence its adoption or non-adoption [12]. A comprehensive and integrative classification which encompasses a benefit-cost analysis is not widely present in NPD literature works. Previous researches [11],[13],[14] only propose perspectives for organizing framework for methods and tools. However, it is essential a classification that helps the practitioners and academics to analyze the trade-off that some companies have to face when applying the methods and tools on their NPD [12].

In order to contribute with the aforementioned gaps, the aims of this research are to analyze the use and usefulness of the methods and tools in NPD of companies, and to present a classification based on the cost-benefit analysis to address the strengths and weaknesses of each one.

This paper is structured as follows. After the enlightenment of the research background (section 1), it is described the research methodology (section 2). Following, the results and discussions are presented (section 3), comprising: the analysis of use and usefulness of NPD methods and tools, and the cost-benefit classification of them. Lastly, a section of final remarks is presented (section 4).

1. Background

The success of NPD is related to the application of best practices [5],[15], which are the activities, methods, techniques and tools that generate the best results for the process [3],[7],[16]. They provide the reach of greater process performance, with positive reflexes in the product. Specially the effective use of methods and tools on NPD can generate satisfactory outcomes for that process [13].

Method is defined as a systemic procedure employed to perform an activity in order to achieve a desired result, whether an information, product or service [17]. Graner and Mißler-Behr [4] affirm that a method can involve the use of tools, which support practitioners when an activity is carried out. In NPD, the methods and tools can enable practitioners to monitor and evaluate the process and product projects systematically [6]. Because of this, in order to improve the NPD, methods and tools have been developed by researchers and practitioners [12],[14],[18].

The adoption of methods and tools can be at the level of company or at the level of individual development projects [13]. Independently of the level of adoption, some internal and external factors may affect the use of methods and tools in the NPD of companies [12]. On the one hand, the internal factors include the usefulness, time, monetary cost, user-friendliness, flexibility and popularity [12]. Additionally, the complexity of methods and tools may influence their use [13]. On the other hand, external influences encompass the project nature, organization, industries and culture [12]. These factors can involve potential benefits or drawbacks for companies and represent critical decision aspects when practitioners are selecting which methods or tools will be implement in the NPD.

According to Maylor [19], the NPD methods and tools can improve flexibility and can affect the manufacturability, time to market, quality and product cost. Also, this author suggests that the use of them can be associated with the integration of engineers, designers, customers and suppliers.

Yeh et al. [6] presented other elements to be considered in NPD system when methods and tools are applied. They are: customer perception, value addition, tangible and intangible outcomes. Furthermore, it has been shown that different methods and tools can be used in various stages of NPD. It should be noted that methods and tools could overlap a NPD stage. In fact, they can be adapted to meet different needs or characteristics of NPD by companies [11].

Some studies [1],[13] reveal that successful projects use methods and tools more frequently than others, even in the early stages of the process. The benchmarking study conducted by the Product Development & Management Association (PDMA) found that best firms use numerous kinds of methods and tools compared to "the rest" [9]. However, the impact on success varies from method-to-method [13] and, consequently, from tool-to-tool.

Regarding the nature of the methods and tools, it is possible compile them in perspectives, which can support an efficient NPD. Some of them are: strategy [3], process [3], market research [3], performance measurement [3], project management [17], knowledge management [20], product [20], organizational culture and climate [3], and information technology [11]. These perspectives allow practitioners selecting and develop appropriate activities using methods and tools in order to increase the process performance. It provides knowledge and experience for companies [13], besides contributes for an effective innovation management of process and product [1].

Thereby, as the NPD is fundamentally multidisciplinary and multifunctional [11], it is important to address the multi-faceted aspects correlated with it for driving the right methods and tools that lead to successful process and products.

2. Research Methodology

In order to reach the aims of this research, firstly the NPD methods and tools discussed in the literature have been consolidated. For it, an exploratory methodological approach was employed and a literature review was carried out. An electronic data-base search was applied to enable a comprehensive search, in which were used the ISI/Web of Science and Scopus databases. Iterative searches were conducted by combining synonyms, acronyms and abbreviation related to the terms "new product development", "practice", "method", "technique", "tool". Boolean search expressions were elaborated, and only studies in English were considered. Two criteria of inclusion were used to select the studies, as follows: investigate the use of methods and tools in the context of NPD and/or show their positive effectiveness. The screening included the title and abstract screening as well as a full copy screening. From these studies, the NPD methods and tools were extracted and coded.

The quantity of methods and tools consolidated from literature review is substantial (one hundred and twenty). Due to that, a selection process of them was conducted. As mentioned previously, the improvement of NPD can be established by the application of practices, as methods and tools. Considering this issue, the resultant findings were associated to improvement projects found in literature consolidated in Costa [20] and Zanatta [21]. The association between the methods and tools with the improvement projects was performed using a qualitative approach based on the content-based analysis, on which the steps adopted were in accordance with the proposal of Bardin [22]. The scope and objectives of the improvement projects were analyzed and interpreted. Then, the methods and tools were related to them. By doing that, a total of fifty more recurrent methods and tools - i.e. that have the highest frequency in the set of improvement projects for NPD - were selected and categorized into NPD perspectives.

To further comprehend the use and usefulness of methods and tools by companies, and in order to examine in what extent their application are costly and beneficial, a workshop was carried out with twenty-four experts on product development – executive managers, project managers, design engineers, among others – by ten manufacturing companies, whose profiles are shown in Table 1.

Table 1. Manufacturing company profiles.

Ref.	Industry Sector	Size
A	Automobile	Medium
B	Automobile	Large
C	Capital goods	Large
D	Dental and hospital	Small
E	Automobile	Large
F	Aviation	Large
G	Chemical	Large
H	White goods	Medium
I	Consumer goods	Large
J	Automobile	Large

The focus group technique [23] was employed. The involvement of the participants was enabled through the application of the card sorting method, which is prescribed when researchers would like to understand how people organize and apply a set of information [24]. As the method name suggests, cards were proposed containing the definition and a predefined classification concerning the fifty selected methods and tools. The preparation stage of cards was performed based on information from literature review. Then, the categories supporting the classification were defined by means of analyses of the main factors that influence the adoption and non-adoption of methods and tools (for it, it was considered the studies of which the methods and tools were extracted). Those factors were defined considering the following criteria: expected impact on NPD, likely contribution for NPD, challenge for application, and effort to implement. The categories are presented in the next sections.

In addition to the preparation stage of cards, the sorting process was also specified. That process allows the grouping of information and the understanding of how practitioners can associate the methods and tools in the categories. Five groups were generated composed by experts of two companies, each one. After the warm-up discussion in order to contextualize the dynamic of the focus group session, the research background and the main goals of the sessions, three stages of focus group were performed: i) recognition of methods and tools by practitioners; ii) real application of the methods and tools in NPD by companies, considering the use and usefulness of each one; iii) classification of methods and tools in accordance with the four categories defined.

The findings of each stage of focus group were consolidated and it is the focus of the following section.

3. Results and Discussion

3.1. Recognition of NPD methods and tools

The most recurrent and relevant NPD methods and tools are consolidated in Table 2. Those methods and tools can be classified in different perspectives of NPD based on the scope of each one. The main perspectives related to the methods and tools listed in Table 2 are strategy, process, market research, performance measurement, project management, product, organizational culture and climate, and information technology. Thus, they can be carried out by different users of NPD, either more or less intensely.

Overall, the practitioners who participated in the workshop knew the methods and tools presented through the cards. They argued that the methods and tools are relatively traditional in the practical application in NPD. A lesser-known method by the ten companies is 'set-based concurrent engineering'. This method encompasses the development and communication "about set of solutions in parallel and relatively independent" [28], not only in the front end of innovation (FEI). As this method is not widely known, it is expected that only few companies use it.

Table 2. Fifty most revelant NPD methods and tools.

Method/Tool	Perspective	Author(s)
Technology and product roadmap	Strategy	[11]
Product portfolio management	Strategy	[11],[25],[26],[27]
Technology trend analysis	Strategy	[11]
Set-based concurrent engineering	Strategy	[28]
Stage-gate	Process	[7],[9],[11],[14],[29]
Flexible process	Process	[5], [27],[29]
Enterprise Resource Planning	Information technology	[11]
Market research	Market research	[5]
Customer observation	Market research	[13]
User-centered design	Market research	[11]
Benchmarking	Market research	[6],[11],[13]
Customer support	Market research	[5]
Customer integration	Culture and climate	[5],[7],[13],[27]
Supplier integration	Culture and climate	[6],[13],[14]
Collaborative Design	Culture and climate	[6]
Cross-functional teams	Culture and climate	[5],[6],[7],[11],[14],[26]
Incentives and rewards	Culture and climate	[5],[9],[25]
Project management	Project management	[6],[11]
Project Management Office	Project management	[17]
Critical path analysis	Project management	[11],[13]
Work breakdown structure	Project management	[17]
Project review meeting	Project management	[5],[11]
Metrics use	Performance measurement	[7],[27]
Knowledge management	Knowledge management	[6],[11]
Training	Knowledge management	[7]
Value engineering	Product	[6],[11],[18]
Financial models	Performance measurement	[11],[13]
Make-or-buy analysis	Product	[13]
Modular design	Product	[6],[13],[14]
Group technology	Product	[6],[13],[14]
Design Failure Mode and Effect Analysis	Product	[6],[11],[13],[14]
Product Failure Mode and Effect Analysis	Product	[6],[11],[13],[14]
Fault tree analysis	Product	[11],[18]
Quality Function Deployment	Product	[6],[11],[13],[14],[18]
Brainstorming	Culture and climate	[6],[11],[13]
Design of Experiments	Product	[6],[11],[18]
Statistical process control	Process	[11],[14]

Method/Tool	Perspective	Author(s)
Product Life-Cycle Management	Information technology	[11]
Product Data Management	Information technology	[6],[14]
Engineering Change Management	Information technology	[11]
Electronic Data Management	Information technology	[11]
Computer-Aided Design	Information technology	[6],[11],[13],[14]
Computer-Aided Engineering	Information technology	[6],[11],[13],[14]
Computer-Aided Manufacturing	Information technology	[6],[11],[14]
Workflow	Information technology	[11]
Design for assembly	Process	[6],[13]
Design for manufacturing	Process	[6],[13]
Design for cost	Process	[11]
Design for reliability	Product	[11]
Design for six sigma	Product/Process	[6],[11],[13]

The results related to the use and usefulness of methods and tools are presented in the following subsection.

3.2. Use and usefulness of NPD methods and tools

Practitioners were encouraged to analyze the applicability and usefulness of each method and tool in accordance with the reality in the NPD of companies. Thus, four classes related to the use or non-use of each one, and the degree of usefulness (very or little useful) were defined. Table 3 presents the percentage of companies that associated the respective method or tool in each class.

Six methods/tools are used and considered very useful by all the companies: stage-gate, cross-functional teams, benchmarking, enterprise resource planning, project management and computer-aided design. This indicates that all the companies use a formal process model of product development, in which the participating team encompasses practitioners from different functions and they act from start to finish of the project. Other practice performed by the companies is the comparision of their process performance in relation to industry leading companies. It helps companies to develop improvement plans. Also, they use an information system to collect and group the data and information regarding the process and product. The use and usefulness of computer-aided design in all the companies show that this information technology can be applied for all type of manufactured products.

Although the project management methods have the highest frequency of use, only five companies have a project management office; not all companies consider it very useful. The practitioners claimed that the methods/tools examined as little useful are not applied under the context of their NPD. This demonstrates that a method and tool are context dependent and they can be more suitable to be used in certain circumstance. At the same time, there are methods and tools used by companies, but assessed as little useful, e.g. brainstorming. In that cases, resources are being spent even not reaching a satisfactory and desired result with the application of the method or tool. Thus, the analysis of the existing and desired situations for NPD is important when selecting which method or tool should be applied.

There are some methods/tools do not widely used by companies, but they are considered very useful. They are: flexible process, collaborative design and knowledge management. Among other methods, set-based concurrent engineering is used only by three companies, but four of them would like to apply it on NPD. Some reasons explained by companies by do not use the methods/tools considered very useful are: financial or cultural aspects and an extended time for implementation.

Table 3. Use and usefulness of methods and tools by companies.

Method/Tool	Uses		Do not use	
	Very Useful	**Little useful**	**Very useful**	**Little useful**
Technology and product roadmap	80 %	20 %	0 %	0 %
Product portfolio management	80 %	0 %	10 %	10 %
Technology trend analysis	90 %	0 %	10 %	0 %
Set-based concurrent engineering	30 %	10%	40 %	20 %
Stage-gate	100 %	0 %	0 %	0 %
Flexible process	50 %	0 %	50 %	0 %
Market research	80 %	0 %	20 %	0 %
Customer observation	50 %	0 %	30 %	20 %
User-centered design	60 %	0 %	10 %	30 %
Benchmarking	100 %	0 %	0 %	0 %
Enterprise Resource Planning	100 %	0 %	0 %	0 %
Customer support	70 %	10 %	10 %	10 %
Customer integration	60 %	0 %	20 %	20 %
Supplier integration	90 %	0 %	0 %	10 %
Collaborative Design	40 %	10 %	50 %	0 %
Cross-functional teams	100 %	0 %	0 %	0 %
Incentives and rewards	50 %	10 %	40 %	0 %
Project management	100 %	0 %	0 %	0 %
Project Management Office	50 %	10 %	30 %	10 %
Critical path analysis	80 %	0 %	30 %	0 %
Work breakdown structure	80 %	0 %	20 %	10 %
Project review meeting	90 %	0 %	10 %	0 %
Metrics use	80 %	10 %	10 %	10 %
Knowledge management	30 %	10 %	60 %	0 %
Training	90 %	0 %	10 %	0 %
Value engineering	50 %	0 %	30 %	20 %
Financial models	80 %	0 %	10 %	10 %
Make-or-buy analysis	80 %	0 %	20 %	0 %
Modular design	70 %	0 %	20 %	10 %
Group technology	90 %	0 %	0 %	10 %
Design Failure Mode and Effect Analysis	90 %	0 %	10 %	0 %
Product Failure Mode and Effect Analysis	80 %	0 %	20 %	0 %
Fault tree analysis	60 %	0 %	40 %	0 %
Quality Function Deployment	70 %	10 %	10 %	10 %
Brainstorming	80 %	20 %	0 %	0 %
Design of Experiments	70 %	10 %	10 %	10 %
Statistical process control	90 %	10 %	0 %	0 %
Product Life-Cycle Management	60 %	0 %	40 %	0 %
Product Data Management	80 %	0 %	20 %	0 %
Engineering Change Management	90 %	0 %	10 %	0 %
Electronic Data Management	90 %	10 %	0 %	0 %
Computer-Aided Design	100 %	0 %	0 %	0 %
Computer-Aided Engineering	80 %	0 %	0 %	20 %
Computer-Aided Manufacturing	80 %	0 %	0 %	20 %
Workflow	80 %	0 %	20 %	0 %
Design for assembly	60 %	0 %	30 %	10 %
Design for manufacturing	90 %	0 %	10 %	0 %
Design for cost	70 %	0 %	30 %	0 %
Design for reliability	90 %	0 %	10 %	0 %
Design for six sigma	50 %	0 %	30 %	20 %

In this context, some factors may influence the adoption of the methods and tools. Therefor, they also influence in their cost-benefit analysis. The factors are presented in the next section, which also presents a classification for the NPD methods and tools.

3.3. Cost-benefit classification of NPD methods and tools

The cost-benefit analysis of NPD methods and tools is proposed by means of a classification which encompasses four criteria. For each one, a category was defined. Table 4 summarizes it.

Table 4. Criteria and categories for classification of methods and tools.

Criteria	Category	Definition	Author(s)
Expected impact	Performance objective	- It includes the performance factors that are reached when a method or tool is applied.	[19]
Likely contribution	Added value	- It concerns the contribution and differentiation of methods or tools for NPD.	[6]
Challenge for application	Complexity	- It refers to the challenge and the team knowledge needed for implementing a method or tool in NPD. Also, it is related to the amount and types of resources involved and the degree of change or adaptation required for the process.	[13]
Effort to implement	Implementation cost	- It is related to the efforts employed to implement a method or tool. It considers e.g. the acquisition of resources and technology, training, staff time spent, etc.	[12]

The classifications, by practitioners, of the methods and tools for each category were consolidated and it is presented in Table 5. Classifications by companies that do not apply the method/tool were not considered. The defined performance objectives are: quality (Q) (even of the process or product, according to the scope of methods/tool), time (T) and cost (C) of development. The range of the other three categories varies and can be: high (↑), medium (→) or low (↓).

All available methods/tools have a high or, at least, medium value added - i.e. they positively contribute for NPD. Almost 62% of methods/tools affect the objectives of quality, time and cost, simultaneously. The methods/tools used for all companies (that were presented in section 3.2) impact on the three performance objectives. The methods/tools do not used by companies, but which were considered very useful, also impact the three performance objectives. This fact indicates the need for improving the NPD of companies. In the cases in which a method/tool is related to a high complexity do not mean that the implementation cost will be high, and vice versa. For example, the design failure mode and effect analysis is associated with a high complexity, but also with a low implementation cost. So, the companies should analyze whether they have the knowledge or efforts required to implement the NPD method or tool.

Thus, this indicates that when performing the cost-benefit analysis, all factors that influence the adoption of a method or tool should be evaluated.

Table 5. Classification of methods and tools.

Method/Tool	Objective	Added value	Complexity	Implementation cost
Technology and product roadmap	Q; T; C	↑	↑	→
Product portfolio management	Q; T; C	↑	→	→
Technology trend analysis	Q; T; C	↑	↑	→
Set-based concurrent engineering	Q; T; C	↑	↑	↑
Stage-gate	Q; T; C	↑	↑	→
Flexible process	Q; T; C	↑	↑	→
Market research	Q; T; C	↑	→	↑
Customer observation	Q; C	→	↑	↑
User-centered design	Q	↑	→	↑
Benchmarking	Q; T; C	→	→	↓
Enterprise Resource Planning	Q; T; C	↑	↑	↑
Customer support	Q; T; C	↑	→	→

Method/Tool	Objective	Added value	Complexity	Implementation cost
Customer integration	Q; C	↑	→	→
Supplier integration	Q; T; C	↑	↑	→
Collaborative Design	Q; T; C	↑	↑	→
Cross-functional teams	Q; T; C	↑	→	→
Incentives and rewards	Q	→	→	↓
Project management	Q; T; C	↑	→	→
Project Management Office	Q; T	↑	→	↓
Critical path analysis	T; C	↑	→	↓
Work breakdown structure	Q; T	↑	→	↓
Project review meeting	Q; T; C	↑	↓	↓
Metrics use	Q; T; C	→	→	↓
Knowledge management	Q; T; C	↑	→	→
Training	Q; T; C	→	→	→
Value engineering	C	↑	→	→
Financial models	C	↑	→	→
Make-or-buy analysis	Q; T; C	↑	→	↓
Modular design	Q; T; C	↑	↑	→
Group technology	Q; T; C	↑	→	→
Design Failure Mode and Effect Analysis	Q; C	↑	↑	↓
Product Failure Mode and Effect Analysis	Q; C	↑	→	↓
Fault tree analysis	Q	→	→	↓
Quality Function Deployment	Q; C	↑	↑	→
Brainstorming	Q; T; C	→	↓	↓
Design of Experiments	Q; T; C	↑	→	→
Statistical process control	Q; C	→	↓	→
Product Life-Cycle Management	Q; T; C	↑	↑	↑
Product Data Management	Q; T	↑	↑	↑
Engineering Change Management	Q; T; C	↑	↑	↑
Electronic Data Management	Q; T	↑	→	→
Computer-Aided Design	Q; T; C	↑	↑	↑
Computer-Aided Engineering	Q; T; C	↑	↑	↑
Computer-Aided Manufacturing	Q; T	↑	↑	↑
Workflow	T	→	→	↓
Design for assembly	Q; T; C	↑	→	→
Design for manufacturing	Q; T; C	↑	→	→
Design for cost	C	→	→	→
Design for reliability	Q	↑	↑	→
Design for six sigma	Q; T; C	↑	↑	→

4. Final Remarks

This study provides a systematic evaluation of some NPD methods and tools. Its main academic and managerial contributions are: i) the systematization of the main NPD methods and tools; ii) the overview of the use, usefulness and attractiveness of them; iii) the introduction, based on a classification, of a valuable cost-benefit analysis that can help companies to improve their NPD. Adopting the involvement of practitioners is also a contribution of this research, once the findings achieved are based on practical perspective encompassing their' point of view. The findings clearly confirm the importance to improve the NPD of companies based on their context, once some methods and tools are considered very useful, but are still not applied. Also, the findings indicate that companies should be prepared to implement the NPD methods and tools, once they are related to different complexity and implementation cost. Next steps of research aim to analyze the selection of methods and tools in accordance with the NPD strategy and case studies will be performed to evaluate their applicability.

References

[1] M. Graner, Are Methods the Key to Product Development Success? An Empirical Analysis of Method Application in New Product Development", In A. Chakrabarti and U. Lindemann (eds): *Impact of Design Research on Industrial Practice*, Springer International Publishing, Germany, 2015, pp. 23-43.
[2] M. Rossi et al., Proposal of an Assessment Model for New Product Development, In C. Emmanouilidis et al. (eds): *Advances in Production Management Systems*, Springer, Berlin Heidelberg, 2013, pp. 383-390.
[3] G. Barczak and K. B. Kahn, Identifying new product development best practice, *Business. Horizons*, vol. 55, 2012, pp. 293–305.
[4] M. Graner and M. M. Behr, The use of methods in new product development - a review of empirical literature, *Int. J. Product Development*, Vol. 16, 2012, p. 158-184.
[5] J. Nicholas, A. Ledwith and H. Perks, New product development best practice in SME and large organisations: theory vs practice, *European J. of Innovation Management*, Vol.14, 2011, pp. 227-251.
[6] T. M. Yeh, F. Y. Pai and C. C. Yang, Performance improvement in new product development with effective tools and techniques adoption for high-tech industries, *Quality & Quantity*, Vol. 44, 2010, pp. 131–152.
[7] M. Rossi, E. Kerga, M. Taisch, S. Terzi, Engineering and design best practices in new product development: An empirical research, *Procedia CIRP*, Vol. 21, 2014, pp. 455–460.
[8] M. Adams, Rejoinders to 'Establishing an NPD Best Practices Framework', *J. Prod. Innov. Manag.*, Vol. 23, 2006, pp. 117–127.
[9] G. Barczak, A. Griffin, and K. B. Kahn, Perspective: Trends and drivers of success in NPD practices: Results of the 2003 PDMA best practices study, *J. Prod. Innov. Manag.*, Vol. 26, 2009, pp. 3–23.
[10] M. Graner and M. Mißler-Behr, Key determinants of the successful adoption of new product development methods, *European J. of Innovation Management*, Vol. 16, 2013, pp. 301–316.
[11] G. A. De Waal, P. Knott, Product development: An integrative tool and activity research framework, *Humans Systems Management*, Vol. 29, 2010, pp. 253-264.
[12] C. W. Thia, K.-H. Chai, J. Bauly, and Y. Xin, An exploratory study of the use of quality tools and techniques in product development, *TQM Mag.*, Vol. 17, 2005, pp. 406–424.
[13] M. Graner, Method Application in New Product Development and the Impact on Product Success, *Int. J. of Innovation and Technology Management*, Vol. 12, 2015, 31 p.
[14] F. J. M. González and T. M. B. Palacios, The effect of new product development techniques on new product success in Spanish firms, *Ind. Mark. Manag.*, Vol. 31, 2002, No. 3, pp. 261–271.
[15] J. Clarkson and C. Eckert, *Design Process Improvement*, Springer, London, 2005.
[16] K. B. Kahn, G. Barczak, J. Nicholas, A. Ledwith, and H. Perks, An examination of new product development best practice, *J. Prod. Innov. Manag.*, Vol. 29, 2012, pp. 180–192.
[17] PMI, *Conhecimento em gerenciamento de projetos*, PMBOK, Brasil, 2008.
[18] M. Leber, M. Bastič, and B. Buchmeister, The Trends in Usage and Barriers of Innovation Management Techniques in New Product Development, *J. Mech. Eng.*, Vol. 60, 2014, pp. 382–388.
[19] H. Maylor, Assessing the relationship between practice changes and process improvement in new product development, *Omega*, vol. 29, 2001, pp. 85–96.
[20] J. M. H. Costa, Método de diagnóstico e identificação de oportunidades de melhoria do processo de desenvolvimento de produtos utilizando um padrão de recorrência de efeitos indesejados, PhD thesis, USP, 2010, [Online]. Available: http://www.teses.usp.br/teses/disponiveis/18/18140/tde-25042011-112003/pt-br.php , Accessed: 16 April 2016.
[21] A. Zanatta, Melhoria do processo de desenvolvimento de produtos de uma empresa de produção de bens de consumo duráveis visando à implementação de um modelo de referência, PhD thesis, USP, 2010, [Online]. Available: http://www.teses.usp.br/teses/disponiveis/18/18156/tde-26112010-153112/pt-br.php , Accessed: 16 April 2016.
[22] L. Bardin, *Análise de conteúdo*. Edições 70, São Paulo, 2011.
[23] F. Rabiee, Focus-group interview and data analysis., *Proc. Nutr. Soc.*, Vol. 63, 2004, pp. 655–660.
[24] D. Spencer, *Card sorting: Designing Usable Categories*, Rosenfeld, 2009.
[25] K. Cormican and D. O. Sullivan, Auditing best practice for effective product innovation management, *Technovation*, Vol. 24, 2004, pp. 819–829.
[26] G. Barczak, K. B. Kahn, and R. Moss, An Exploratory Investigation of NPD Practices in Nonprofit Organizations, *J. Prod. Innov. Manag.*, Vol. 23, 2006, pp. 512–527.
[27] R. Cooper, *Formula for Success in New Product Development*, Stage-Gate Inc., 2006, pp. 1-9.
[28] E. Kerga, M. Rossi, M. Taisch, and S. Terzi, A serious game for introducing set-based concurrent engineering in industrial practices, *Concurr. Engin. Res. Appl.*, Vol. 22, 2014, pp. 333–346.
[29] B. R. G. Cooper and S. J. Edgett, Best Practices in the Idea-to-Launch Process and Its Governance, *Research-Technology Management*, 2012, pp. 43–54.