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Review

New Product Development Process Design for Small and Medium Enterprises: A Systematic Literature Review from the Perspective of Open Innovation

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Abstract: New product development (NPD) is essential for large, as well as small and medium, enterprises (SMEs). Despite its importance for the economy, challenges remain in the NPD in SMEs. Product success is related with the NPD process, so it is important for SMEs to be able to design their NPD process. This paper aims to identify SME's NPD research topics, the characteristics of the NPD process in SMEs, and important aspects to be considered for NPD process design. The literature review is done with the analysis of 99 selected academic articles from Scopus and ScienceDirect. Content analysis, bibliographic analysis, and clustering method (based on Pearson's correlation coefficient) are used to conduct the identification. Less-formal processes, informal strategic planning, limited resources, need technology support, and lack of capabilities in certain fields are some of the characteristics of SME's NPD. Collaborative product development, competitive advantage, information and communication technology (ICT), concurrent engineering, quality function deployment, and continuous improvement are important keywords based on previous research in SME's NPD. Design activities in NPD, collaboration and source of innovation, and process modelling, tools, and techniques appear to be important aspects related with the SME's NPD process.

Keywords: new product development process; small medium enterprises; open innovation; literature review; product design and development; process design

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1. Introduction

New product development (NPD) is essential for business. Development and commercialization of new products give competitive advantages and are very important for company's growth and sustainability [1–3]. Nevertheless, achieving successful product development projects is still a challenge [4,5]. Prior studies identified that the NPD process is an important key success factor for product development [4–11]. The NPD process is defined as designed specific steps that describe how an organization transforms their product idea into marketable products [12]. While several issues on the NPD process; such as the NPD process in the context of Industry 4.0 [13], social product development process [14], how digital tools change the NPD process [15], knowledge sharing in NPD processes [16], and resource allocation in NPD processes [17]; have emerged and been studied, it is agreed that an organization needs to design their own NPD process that fits with their strategic goals and situations [3,18,19], and open innovation can help SMEs overcome their innovation issues [20].

The inevitability of NPD is not only relevant to large scale companies, but also for small and medium enterprises (SMEs) [21]. In fact, SMEs have a significant role in the economic development of a country [22]. NPD in SMEs may differ from large firms [23]. A recent literature study on NPD suggests that NPD processes outside large companies should be further studied [24]. It is important for SMEs to be able to design their NPD process. Although studies on the NPD process design have been done: Loch [19] addressed

the NPD process design issue in a large firm and proposed technology newness and market newness as a base for NPD process; and Unger and Eppinger [18] proposed steps to design a NPD process based on risks, but a focus on designing a SME's NPD process is still needed.

To be able to support the design of a NPD process for SME, it is important to conduct a literature study to gain a view of the previous research findings related to the SMEs' NPD process. Horte [25] performed a literature study on SMEs' NPD and organized the studies into three main areas: management (covering topics such as leadership, finance, and business environment), operations (covering topics such as methods and techniques, NPD process, and supply chain), and performance, i.e., link NPD with growth and performance. Based on the confidence that the literature concerning SMEs' NPD has been carefully explored, this study aims to go one step further by exploring deeper and overlooked issues regarding the NPD process in SMEs. Therefore, the purpose of this review article was to identify the NPD process in SMEs with the following research questions:

RQ 1: What are the topics of previous studies on the NPD process in SMEs?
RQ 2: What are the characteristics of the NPD process in SMEs?
RQ 3: What are the important aspects to be considered for SMEs' NPD process design?

2. Materials and Methods

2.1. Analytical Procedure

The research papers selected from the literature focus on the topic of NPD in SMEs. A review was conducted following the steps by Godinho Filho and Saes [26] as follows:

- Step 1: Find articles related to the topic.

The first step is to find relevant academic articles. The database is from Scopus and ScienceDirect. The search process is based on keywords that represent the NPD and SMEs and used to ensure the articles collected represent the topic discussed. Next, the articles are filtered to remove duplications. Two step filtering is then applied. Firstly, the articles are screened based on the titles and abstract. The abstract is a representation of the article, and consists of purpose, method, and results of the research, therefore it is a good approach for examining articles [27]. The inclusion criteria are that the articles discussed both the NPD process and SME. Secondly, after title and abstract screening, full-text review is conducted.

- Step 2: Decide the classification of articles.

Articles are classified to identify themes of research. The classification is performed using clustering based on words similarity. NVIVO 12 software is utilized to perform the clustering. The software detects the words in the article and clustered the articles based on its word similarity. In addition, descriptive analysis is also performed to identify the most cited articles, research approach, region of study, industry sectors, and keywords analysis.

- Step 3: Group the articles based on the classification.

Based on the clustering result, the articles are grouped.

- Step 4: Elaborate the result.

Content analysis is implemented to elaborate the classification result. The analysis is based on the article text, of which it is believed to be a valuable data source [28]. Each article is carefully read, and the themes of research are identified. Results from descriptive analysis are also elaborated.

- Step 5: Identify the opportunity for future research.

Finally, a future research opportunity is identified based on the elaboration result. We recommend some of the future research for SMEs' NPD.

2.2. Data Collection

We use Scopus and Science Direct as the database of this study. The term used is based on the process (NPD) and organization (SME) side. There are 15 searches for articles and reviews based on the title, abstract, and author keywords. The searches are of "Product

Development" AND "Small Medium Enterprise", "Product Development" AND "Small and Medium Enterprise", "Product Development" AND "SME", "New Product Development" AND "Small Medium Enterprise", "New Product Development" AND "Small and Medium Enterprise", "New Product Development" AND "SME", "Product Design" AND "Small Medium Enterprise", "Product Design" AND "Small and Medium Enterprise", "Product Design" AND "SME", "Product Development Process" AND "Small Medium Enterprise", "Product Development Process" AND "Small and Medium Enterprise", "Product Development Process" AND "SME", "New Product Development Process" AND "Small Medium Enterprise", "New Product Development Process" AND "Small and Medium Enterprise", and "New Product Development Process" AND "SME" keywords.

Previous literature studies on the NPD area have a diverse period of articles included in their analysis. In their study about intellectual structure of product innovation research, Durisin, Calabretta, and Parmeggiani [29] analyzed articles in a 20-years period. Guo [27] analyzed the streams of NPD research in a 22-years period. Papastathopoulou and Jan Hultink [30] used 27 years of articles to examine research on New Service Development (NSD), explaining that the time range is started at the time that the first article on NSD was published in an academic journal. There are also studies that have a shorter period, such as Perks and Roberts' review on longitudinal studies of product innovation [31] (11 years), Horte et al.'s review on SME's NPD (including management, operations, and performance) [25] that included articles in a 15-years period, and Marzi et al.'s [24] review on NPD research for the last ten years. Marzi et al. explain that the period is based on previous literature studies and intended to enrich the knowledge, especially in the engineering and business aspects, of NPD [24]. It seems that if the issues have been studied before, it is best to limit the period so that it can complement prior research. To our knowledge, a literature study of the NPD process in SMEs has not been explored yet. Therefore, there is no specific year restrictions for the articles in this study. It is expected that this will give more insight on the issues.

The initial search yielded 1285 documents. This vast collection of documents is filtered so that it aligned with the research questions. First the filter aimed to removing item duplications, reducing the portfolio to 606 documents. Discussions on SMEs are also linked with financial and organizational communication, supply chain, and production, which are not relevant with the focus on NPD. Based on the titles and abstract, a second filtering was conducted to select articles that focus on the NPD process, resulting in 177 documents. Next, using the same criteria that only articles focusing on the NPD process in SMEs will be further analyzed, we performed a full-text review. To ensure the scientific quality of the research, only articles published in journals with a double-blind review process were included. This is the most exhaustive filtering process, yielded 99 articles relevant to the NPD process pertaining to SMEs. The process is illustrated in Figure 1.

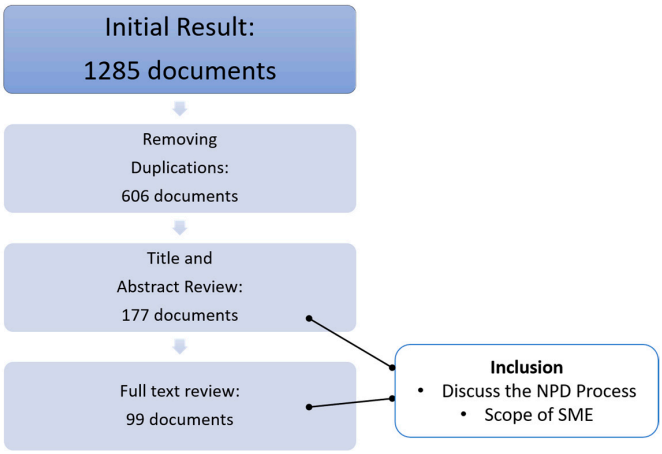

Figure 1. Articles filtering process.

3. Descriptive Analysis Result

3.1. Articles Overview

The database of articles consists of 99 papers, with the publication year from 1996 to 2019. The distribution of articles based on the year is shown in Table 1 and Figure 2.

Table 1. Distribution of articles by years.

Year	Number of Articles
1996	1
2001	1
2002	5
2003	3
2004	4
2005	4
2006	6
2007	3
2008	4
2009	3
2010	5
2011	4
2012	5
2013	5
2014	5
2015	6
2016	10
2017	2
2018	7
2019	11

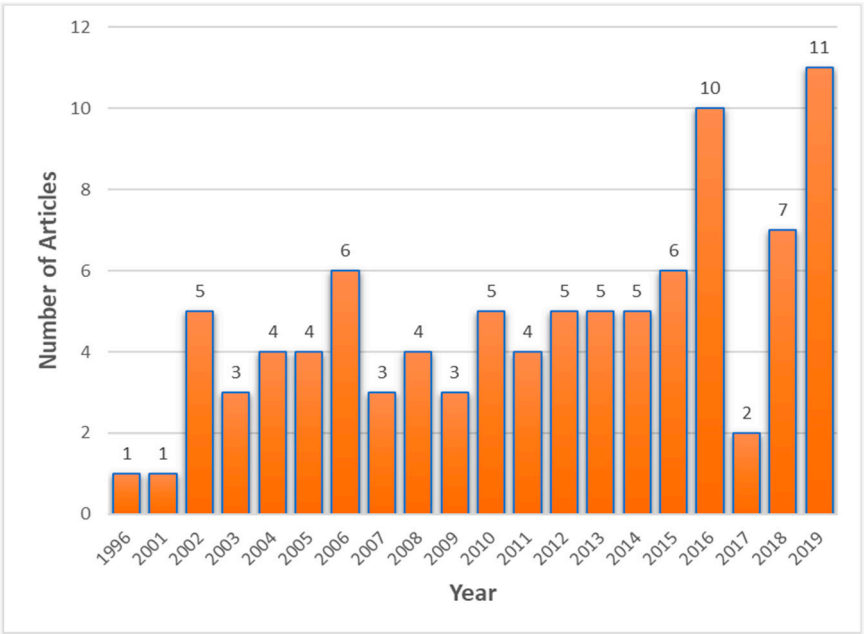

Figure 2. Distribution of articles by years.

The articles have the total citations of 1838. Among them, the most cited articles are listed in Table 2.

Table 2. Most Cited Articles.

No	Authors	Title	Year	Journal	Total Citation	Citations/Year
1	Le Pochat, S., Bertoluci, G., Froelich, D.	Integrating ecodesign by conducting changes in SMEs	2007	Journal of Cleaner Production	117	9.75
2	Huang, X., Soutar, G.N., Brown, A.	New product development (NPD) processes in small and medium-sized enterprises: Some Australian evidence	2002	Journal of Small Business Management	90	5.29
3	March-Chordà, I., Gunasekaran, A., Lloria-Aramburo, B.	Product development process in Spanish SMEs: An empirical research	2002	Technovation	84	4.94
4	Allocca, M.A., Kessler, E.H.	Innovation Speed in Small and Medium-Sized Enterprises	2006	Creativity and Innovation Management	80	6.15
5	Chen, Y.-S., James Lin, M.-J., Chang, C.-H.	The influence of intellectual capital on new product development performance—The manufacturing companies of Taiwan as an example	2006	Total Quality Management and Business Excellence	77	5.92
6	Kusar, J., Duhovnik, J., Grum, J., Starbek, M.	How to reduce new product development time	2004	Robotics and Computer-Integrated Manufacturing	65	4.33
7	Bommer, M., Jalajas, D.S.	Innovation sources of large and small technology-based firms	2004	IEEE Transactions on Engineering Management	64	4.27
8	Kaminski, P.C., de Oliveira, A.C., Lopes, T.M.	Knowledge transfer in product development processes: A case study in small and medium enterprises (SMEs) of the metal-mechanic sector from São Paulo, Brazil	2008	Technovation	59	5.36
9	Mosey, S.	Understanding new-to-market product development in SMEs	2005	International Journal of Operations and Production Management	55	3.93
10	Knauber, P., Muthig, D., Schmid, K., Widen, T.	Applying product line concepts in small and medium-sized companies	2000	IEEE Software	50	2.63
11	Corso, M., Martini, A., Paolucci, E., Pellegrini, L.	Knowledge management configurations in Italian small-to-medium enterprises	2003	Integrated Manufacturing Systems	49	3.06
12	Giannini, F., Monti, M., Biondi, D., Bonfatti, F., Monari, P.D.	A modeling tool for the management of product data in a co-design environment	2002	CAD Computer Aided Design	48	2.82
13	Nicholas, J., Ledwith, A., Perks, H.	New product development best practice in SME and large organizations: Theory vs practice	2011	European Journal of Innovation Management	48	6.00
14	De Massis, A., Kotlar, J., Frattini, F., Chrisman, J.J., Nordqvist, M.	Family Governance at Work: Organizing for New Product Development in Family SMEs	2015	Family Business Review	45	11.25

Table 2. *Cont.*

No	Authors	Title	Year	Journal	Total Citation	Citations/Year
15	De Toni, A., Nassimbeni, G.	Small and medium district enterprises and the new product development challenge: Evidence from Italian eyewear district	2003	International Journal of Operations and Production Management	45	2.81
16	Hernández Pardo, R.J., Bhamra, T., Bhamra, R.	Sustainable product service systems in SMEs: Opportunities in the leather manufacturing industry	2012	Sustainability	43	6.14
17	Woodcock, D.J., Mosey, S.P., Wood, T.B.W.	New product development in British SMEs	2000	European Journal of Innovation Management	43	2.26
18	Lindman, M.T.	Open or closed strategy in developing new products? A case study of industrial NPD in SMEs	2002	European Journal of Innovation Management	41	2.41
19	Owens, J.D.	Why do some UK SMEs still find the implementation of a new product development process problematical? An exploratory investigation	2007	Management Decision	41	3.42
20	Buttol, P., Buonamici, R., Naldesi, L., Rinaldi, C., Zamagni, A., Masoni, P.	Integrating services and tools in an ICT platform to support eco-innovation in SMEs	2012	Clean Technologies and Environmental Policy	36	5.14

3.2. Research Approach

The articles were categorized based on the methodological and analytical approaches used. This categorization is referred to in the literature review on SMEs' NPD by Horte et al. [25]. The result is shown in Table 3.

Table 3. Research approach.

			Methodological Approach			Total
			Conceptual	Empirical Qualitative	Empirical Quantitative	
Analytical Approach	Descriptive	Count	0	48	26	74
		% of Total	0.0%	48.5%	26.3%	74.7%
	Explanatory	Count	0	0	5	5
		% of Total	0.0%	0.0%	5.1%	5.1%
	Explorative	Count	9	8	3	20
		% of Total	9.1%	8.1%	3.0%	20.2%
Total		Count	9	56	34	99
		% of Total	9.1%	56.6%	34.3%	100.0%

Most of the studies' analytical approach is descriptive (74.7%). Based on a methodological approach, 56.6% of research uses empirical qualitative and 34.4% of research uses empirical quantitative.

3.3. Region of Study

Most of the studies concern Europe, although trends show that since 2004, various regions have been investigated. The volume of studies that concern Asia remains mostly consistent over time. The region of study is shown in Figure 3.

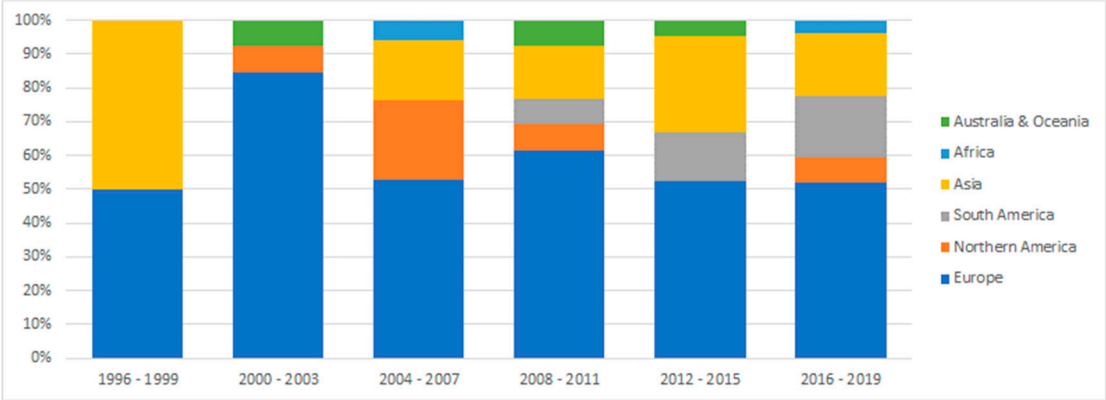

Figure 3. Region of study.

3.4. Industry Sectors

Numerous industry sectors have been studied, and the variation of the industry is growing. In the period 1996–2003, besides sectors such as machinery and equipment, medical, and manufacturing of computers, electronic, and optical products, there is also a concern in software and IT sectors. Starting from 2004, various sectors, including software and IT, telecommunications, even retail and financial and insurances are being studied. The industry sectors are shown in Table 4.

Table 4. Industry Sectors.

Period	Sectors
1996–1999	Transport Equipment, Metal Manufacture
2000–2003	Computer, Electronic, and Optical; Software and IT; Machinery and Equipment; Metal Manufacture; Chemical; Food and Beverages; Textiles, Wearing Apparel, Leather; Wood and Paper; Medical
2004–2007	Computer, Electronic, and Optical; Software and IT; Machinery and equipment; Chemical; Food and Beverages; Textiles, Wearing Apparel, Leather; Wood and Paper; Medical; Scientific and Technical; Electrical Equipment; Transport Equipment; Telecommunications
2008–2011	Computer, Electronic, and Optical; Software and IT; Machinery and equipment; Metal Manufacture; Food and Beverages; Wood and Paper; Medical; Financial and Insurances
2012–2015	Computer, Electronic, and Optical; Software and IT; Machinery and equipment; Metal Manufacture; Chemical; Food and Beverages; Textiles, Wearing Apparel, Leather; Wood and Paper; Medical; Telecommunications; Transport Equipment; Scientific and Technical; Electricity, Gas, Steam, and Air Conditioning; Rubber and Plastic; Retail
2016–2019	Computer, Electronic, and Optical; Software and IT; Machinery and equipment; Metal Manufacture; Food and Beverages; Textiles, Wearing Apparel, Leather; Wood and Paper; Medical; Transport Equipment

In the period of 2016–2019, a wide variation of industries was studied. It included, to name a few, food and beverages, computer, electronic, and optical, software and IT,

and medical. It seems that the NPD issues in technology-based SMEs and traditional manufacturing firms have gained more attention in research, as shown in Figure 4.

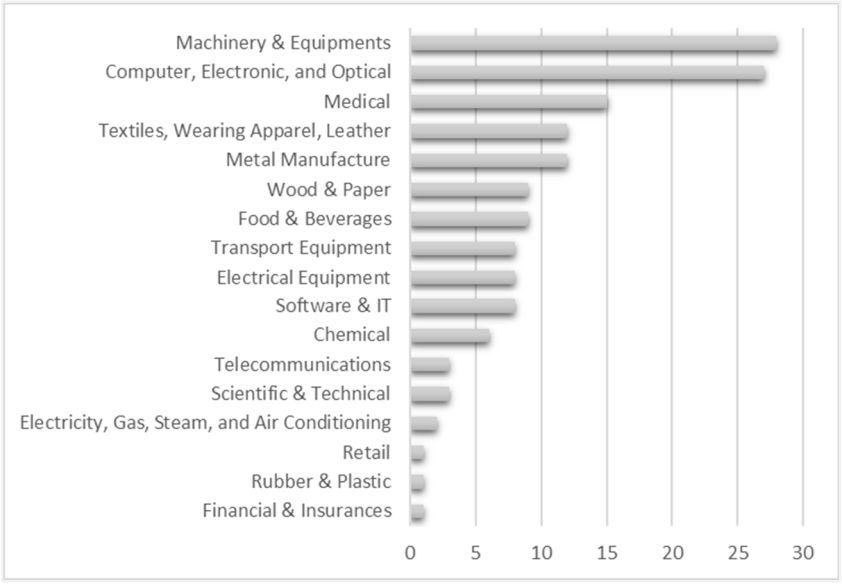

Figure 4. Industry sectors.

3.5. Keywords Analysis

To map the topics covered in the articles, a bibliographic analysis was conducted. Here, the co-occurrence of terms in author keywords was visualized based on the number of keywords that were used in the articles. Keywords that most likely emerged because of the search criteria (such as "new product development" or "SMEs") are not further discussed. The result is shown in Figure 5.

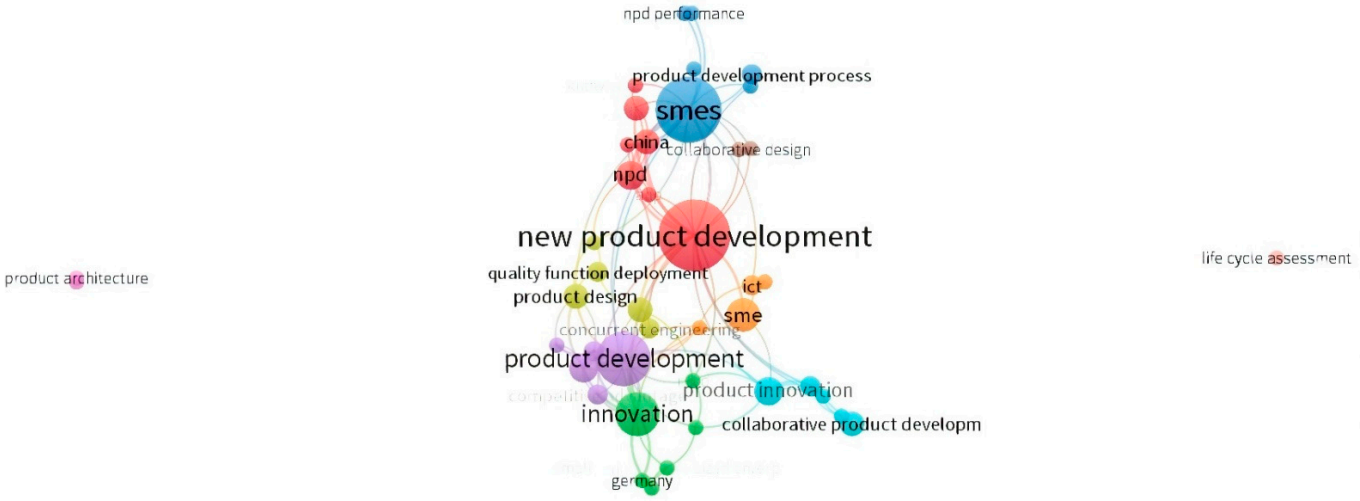

Figure 5. Keyword's analysis.

Occurrence tells the number of documents that include a certain keyword [32], therefore it can help us identify what are the topics that which is of concern in previous studies. The result is shown in Table 5.

Table 5. Keyword's analysis.

Keywords [1]	Occurrences [2]
Collaborative product development	4
Competitive advantage	3
ICT	3
Concurrent engineering	3
Quality function deployment	3
Continuous improvement	2

[1] Keyword that emerged because of search criteria (such as "new product development") is not included. [2] Six highest occurrences.

Several terms that have high occurrence include "collaborative product development", "competitive advantage", "ICT", "concurrent engineering", "quality function deployment", and "continuous improvement". This may reflect the important issues that are faced by SME related to their NPD process. Collaboration is essential, as SMEs consider customers, suppliers, and other stakeholders crucial for their NPD process [33,34]. NPD is an important mean for competitive advantage. Quality Function Deployment is a powerful tool that has been extensively used in NPD process. ICT may reflect the needs of technological support in NPD process. Concurrent engineering can support development time efficiency. Continuous improvement may represent the awareness of process management in SMEs' NPD.

4. Literature Review Result

4.1. Characteristics of SME's NPD Process

SMEs' NPD process is not the same as that in large firms [35,36]. Although there are numerous NPD process models, SMEs still experience difficulty in establishing the appropriate approach [21]. The characteristics of SMEs' NPD process practices are identified to support the design process. The result is shown in Table 6.

Table 6. Characteristics of SMEs' NPD process.

Characteristics of SME's NPD Process	References
Less formal Processes	[21,37–40]
Informal Strategic Planning	[38,41–43]
Limited Resources	[39,40,44–53]
Centralized Decision- Making	[40,43,51,54,55]
Need Adaptive, Easy-to-Use Design Methods	[36,41,42,54,56–60]
Constantly Changing Priorities	[52,61]
Need to Anticipate Risks and Challenges	[50,54,62]
Need Technology Support	[44,47,51,58,59,63–65]
Lack of Milestones in Processes	[21]
Lack of Capabilities in Certain Fields	[39,40,45,47,48,51,54,55,58,63,65]
Has the Potential to be Agile and Adaptive	[37]
Externals Involvement is Crucial in Certain Processes	[33,39,41,44,50,56,57,61,63,66,67]
Autonomy of Projects	[68]
Limited Data Management	[69,70]
Need of Considering Various Design Aspect	[71]
Utilize Software Tools	[41,42,51,57]
Involving Multidisciplinary Team-Working	[35,46,68,72]
Close Relationship with Customers	[33,49,73,74]

The NPD process in SMEs tends to be less formal. This may influence the speed of development as the completeness of steps become an issue [38]. While the strategic direction is the starting point of the NPD process, it is found that SMEs practice informal strategic planning. Milward, Byrne, and Lewis [43] identified that the key person in SMEs sometimes handles various decision-making, including in technical and strategic aspects.

Limited resources are one of the problems faced by SME. It may impact the design of the NPD process, as resources are important to process execution. Centralized decision-making may result in process inefficiency but may also support good monitoring and governance of the process. In addition, SMEs need to properly implement relevant design methods. Method of forecasting and prototyping can help to accomplish product design activities [36]. Priorities are another NPD issue that needs to be tackled by SMEs. The NPD process should be able to capture the dynamics of the environment that might force the company to rearrange its priorities. In a dynamic environment, it is important to be able to anticipate risks. The NPD process should accommodate the identification and anticipation of risks. Technology support can help SME in their NPD process. Kaljun and Dolšak [58] highlight the lack of existing computer tools for ergonomic design and propose the integration of ergonomic design knowledge in the decision support system. In executing the process, SME may experience a lack of milestones. It is important to have the aspects of completion in the NPD process. Issues on capabilities are also faced by SME. The NPD process involves various aspects and multidisciplinary analysis. Arfi, Enström, Sahut, and Hikkerova [45] proposed the knowledge-sharing platform to support a firm's ability to perform its knowledge-sharing scheme. SMEs, due to their relatively small size, have the potential to be agile [37], and the autonomy of projects can be adapted [68]. Furthermore, external involvements are important to support the NPD process. The role of open innovation seems to be relevant with this matter. Integration [66,67] has been an interesting issue for SMEs' NPD process. Limited data management and the requirement to consider various design aspects is another issue that needs to be addressed [69–71]. In addition, SMEs have utilized software tools involving a multidisciplinary team and have the potential to build a close relationship with the customer [33,41,42,49,51,57,73,74].

4.2. Themes of Research

To identify the theme of the research, a two-step analysis is conducted. Firstly, we perform a clustering analysis based on words similarity of the documents. A distinct word is important in clustering because words represent concepts [75]. The clustering is based on Pearson's correlation coefficient using the NVIVO 12 software. There are 4851 correlation coefficients measured with the highest value of 0.8684 and the lowest value of 0.0847. Secondly, we perform a full-text analysis on the articles in each cluster to obtain the themes. There are three main themes in the SMEs' NPD process that have been identified, i.e., design activities in NPD, collaboration and source of innovation, and process modelling, tools, and techniques. It is important to understand the themes as a research emphasis, rather than a strict topic categorization. For example, the article "Integrating EcoDesign by Conducting Changes in SMEs" [76] discusses the EcoDesign Integration Method for SMEs (EDIMS), a method developed as software program to facilitate integration of ecodesign in companies. The method is based on an environmental analysis tool called TEA (Typological Environmental Analysis). Emphasis on implementation of the method and tool is the reason that it seems logical to classify the study in the 'process modelling, tools, and techniques' theme; although the scope of the study is in the conceptual and detail design of the product development process, and discussion about the need of collaboration between purchasing, logistics, and marketing department is also covered.

4.2.1. Design Activities in NPD

Research on this category highlights the design phase or aspect of the NPD process, including the tools and techniques that relevant with this phase.

(a) *Simulation can be used to support design activities.* Ma [77] discussed a web service-based multidisciplinary collaborative simulation platform that can support the Computer Aided Engineering (CAE) analysis. A simulation platform to support collaborative product design for engineering products is also considered important and has been proposed and tested [65].

(b) *Design evaluation should also be considered in NPD process*. Cantó, Frasquet, and Irene [78]; Moultrie, Clarkson, and Albert [71] proposing approach to assess the design from the process and product point of view. Tan [79] elaborates AHP and Grey Relational Analysis's implementation to support the green product design evaluation. The utilization of AHP, combined with Fuzzy Theory and Evidential Reasoning (ER), seems relevant to support the environmental impact evaluations of design options [80]. Not only environmental aspects, but consideration of economic and societal benefits also motivate the development of LICARA nanoSCAN—a modular web-based tool for assessing nanoproducts [81].

(c) *Customer's consideration and involvement in the design process is pivotal for SMEs.* A methodological framework supported by web-based software tools to support the user-centered design along the NPD process has been proved as "flexible, accessible, and easy-to-use" for SME [51]. Another user-centered design topic, related to ergonomic aspect, is discussed by Kaljun and Dolšak [58]. They present how ergonomic design knowledge is integrated in a decision support system. Germani, Mengoni, and Peruzzini [57,82], and Giannini et al. [83] explored the possibility of using the platform to support the co-design process, utilizing tools such as CAD, and methods such as quality function deployment (QFD). Zheng et al. [34] proposed a flexible design approach for robotic systems, accommodating the interactions between customers, designers, and component suppliers. To accommodate the standardization of the development process in the mold industry, the design chain operations reference model was developed by Lyu and Chang [84], enabling a more efficient collaborative design process. The design activities in the NPD process should be prepared so that it can result in desirable product design.

4.2.2. Collaboration and Source of Innovation

The NPD process is involving several stakeholders. Organization needs to collaborate and utilize their sources of innovation. The discussion of collaboration and source of innovation is found in the SMEs' NPD literature. It seems that open innovation is pivotal for SMEs' NPD. Interestingly, the source of innovation differs between large and small firms [33] or between regions [85]. Woodcock, Owen, and Woods [52], and Owens [86] studied the NPD process in the UK and found that a formalized process, formal competitor analysis, data management, involvement of manufacturing in the development process; senior management, environment, and resources support; and early collaboration between functions are required. From the perspective of open innovation, some issues that can be uncovered are:

(a) *Open Innovation—Collaboration with customers—considered as an important action for SME's NPD*. Morgan et al. [87] find that collaboration with the customer could speed up their NPD process. A study on Pakistan's apparel industry revealed that customer collaboration is one way to avoid customer dissatisfaction, and its implementation is influenced by firm's awareness and trust [88].

(b) *Technology's role in collaboration and innovation sourcing also studied in several research*. Innovation capability could be improved if SMEs are supported by IT systems [89] and capabilities, which include the e-collaboration capability [90]. In a study of SMEs' NPD in Niagara region, Canada, Bagchi-Sen concludes that IT is beneficial for the firm's NPD process. External collaborators of firms are those that included suppliers, distributors, and customers [63]. Adoption of technology from external sources, marketing skills, product strategy, and execution of activities; identified as one of the important factors for NPD's success [91].

(c) *Collaboration and source of innovation in technology-based firms is a topic that also emerged.* This may due to the rapid technological changes that forced companies to develop their products faster [38]. Formal communication within teams, process proficiency, filing, project deadlines, and information coding are critical for new product success in high-tech SMEs [62].

(d) *Collaboration between functions is considered important for NPD process.* Cheng identified that marketing-manufacturing interaction may lead to successful NPD [92]. Mendes and Toledo studied concurrent engineering in Brazilian SMEs that do their business in medical device industry and use integration, cross-functional teams, and leadership to identify the organization characteristics [93]. Concurrent engineering is relevant for the SMEs in medical industry and "SMEs can use their informal meeting during the design process as a modified gate system to select winning concepts and monitor the project progress through the development cycle" [93]. Ledwidth [35] suggested that to increase their new product and organizational performance, "improving the product launch process, maintaining a high level of competitor and customer orientation, and inter-functional coordination" need to be done. In a framework of the new-to-market development process, Mosey [94] suggested the involvement of cross-functional teams with a senior manager's participation for the four process area, i.e., product strategy, NPD management, market intelligence, and opportunity identification. It is also identified that external sources of technology and market opportunity can come from customers, suppliers, and competitors. Internal collaboration seems to be an important aspect for firms. A study on the Finnish metal industry SMEs indicates that closed NPD strategy and reliance on their internal resources may help achieve product performance [95]. Lindman, Scozzi, and Otero-Neira [73] studied SMEs in the furniture industry in Italy, Spain, and Finland and identified that management education and interest in design can be an important source of innovative designs. Gurau [54] explored the internal and external sources as the basis for flexible risk management in NPD. Chen [79] elaborated that intellectual capital is important for product development. Nicholas, Ledwith, and Perks [40] revealed that, beside strategy, a competent cross-functional team is considered a best practice for NPD. Besides collaboration with known parties such as suppliers and customers, interaction with other sources also have the potential to support the NPD process. Buganza, Colombo, and Landoni [96] conclude that by focusing on technology and project management capabilities, SME can have benefits from their collaborations with universities for their NPD.

4.2.3. Process Modeling, Tools and Techniques

The execution of process is related to the tools and techniques used. Research on this category is related with the insight on various tools and techniques in the NPD process.

(a) It seems that there are tools that have the potential to support the NPD process, but have not been utilized. Linking NPD situations with tools needed may be a good way for designing the NPD process. In a study of NPD in multiple technology-based SMEs, Salgado, Salomon, Mello, and da Silva [97] identified that tools such as Technology Road mapping (TRM), QFD, Failure Mode and Effect Analysis (FMEA), Design for X (DFX), and others are not being fully utilized, but tools such as CAD and financial analysis are already being used. In an evaluation of product development methodologies of SMEs in metal-mechanic sector, Kaminski, Oliveira, and Lopes [42] identified that CAD and numeric computation software is utilized to support the creation and modification of the product, but PDM/PLM has not been utilized. In their study of NPD process of Swiss' SMEs, Heck and Meboldt [70] conclude that "means are needed to support SMEs in tackling challenges in the product development process".

(b) Determining the specific NPD process for organizations is considered important as organizations' NPD situations vary. Ocampo and Kaminski [98] suggest a 10 stages development process for SMEs in medical device business. The process includes strategic planning, feasibility study, detailed design, and discontinuance; grouped into pre-development, development, and post-development. In a study on NPD process of various SMEs in Spain, March-Chordà, Gunasekaran, and Lloria-Aramburo [99] discover that the NPD sequence is "rather simple and short: 'original idea-brief development-prototype-fabrication'," with an average development time of six months. Textile,

electronics, and metallurgical are sectors with the most rapid changes in its products. Focusing on the pre-development process of food and beverages SME [37] uncovered that idea generation, a first pre-development activity, can be implemented with supporting tools such as creative technique, brainstorming, benchmarking, and QFD. Formal assessment technique might also give an advantage in development time and product quality.

(c) Challenges in the implementation of tools, techniques, and approaches should also be considered in NPD process design. Filson and Lewis [61] address the cultural issues faced by the electronic component manufacturer's in implementing concurrent engineering. Their study indicates that there should be awareness in all levels within the company that the current approach may not be reliable to deliver expected goals. Milward, Dorrington, and Lewis [100] studied the implementation of design-led technology in three manufacturing SMEs in the UK and revealed that CAD/CAM-based systems' implementation has positively impacted product development time, cost, and product quality. Nevertheless, a systematic NPD process is still needed to overcome the firm's dependency on the manager's role.

(d) Consideration of product architecture is also important. Ulonska and Welo [101] proposed Product Portfolio Map, a visual tool for structuring a product portfolio based on architecture analysis; Yan and Stewart [102] introduced GeMoCURE, a modular product design methodology that can help achieve modular product design, which is still a challenge for SMEs. The implementation in a manufacturing SME has uncovered the needs for a standardized system of interfaces. Knauber, Muthig, Schmid, and Widen applied the PulSE, a product line software engineering method. The concept of architecture is applied to software development to help the company introduce new products [103].

(e) Approaches and Tools that enable the acceleration of NPD process is also an emerging issue. de Beer, Booysen, Barnard, and Truscott [104] implement rapid tooling to support accelerated NPD. Team and workgroup issues in applying concurrent engineering were studied by Kusar, Duhovnik, Grum, and Starbek [72]. Concurrent engineering is a potential approach to address development time reduction needs, resulting in a 52% reduction in development time and 13% reduction in development cost. They proposed a team configuration that consists of the core team's permanent structure and the variable structure of the development team. Edwards, Cooper, Vedsmand, and Nardelli [105] apply the Agile–Stage-Gate Hybrid model, a development model combining the Stage-Gate and agile principles that intended to serve the needs of efficient development time and quality assurance, in three manufacturing SMEs. The result is promising as faster development time, higher success rates, and a generally improved development process are achieved.

(f) Specific product requirements can be an important aspect of a company's business. The environmental factor may play a strategic role for certain products. Le Pochat, Bertoluci, and Froelich [76] developed a software program called the EcoDesign Integration Method for SMEs (EDIMS). The software is used to facilitate the ecodesign implementation in an SME. Favi, Germani, Mandolini, and Marconi [106] studied the implementation of a software platform to support an ecodesign methodology. The study indicates that there are positive results, as it is applicable to be integrated in the existing process and can support the utilization of various tools. As technology advances, the approach on the development process also evolves. Niu, Qin, Vines, Wong, and Lu [60]; Qin, Van der Velde, Chatzakis, McStea, and Smith [107] elaborated a crowdsourcing approach for the product development process. Collaboration tools also emerged as important issues as scholars focus their research on this. David and Rowe [108], Aziz, Gao, Maropoulos, and Cheung [56], and Fagerstorm and Jackson [109] explored the collaboration aspects of SME's NPD process. The elaboration of tools and techniques is important when conducting NPD process design for SME.

5. Conclusions

These are the conclusions of this study:

RQ 1: What are the topics of previous studies on the NPD process in SMEs? Topics related to SMEs' NPD from previous studies include collaborative product development, competitive advantage, ICT, concurrent engineering, quality function deployment, and continuous improvement. Collaboration with stakeholders is important for SMEs' NPD. Tool supporting quality and development time considerations are another issue that interest researchers regarding SMEs' NPD. They also need technological support, and awareness of process management also emerged as an issue in SMEs' NPD.

RQ 2: What are the characteristics of the NPD process in SMEs? The characteristics of SMEs' NPD process include low formality, informal strategic planning, limited resources, centralized decision-making; need for adaptive, easy-to-use design methods; constantly changing priorities, need to anticipate risks and challenges, need for technological support, lack of milestones in processes, lack of capabilities in certain fields, having the potential to be agile and adaptive, external involvement is crucial in certain processes, the autonomy of projects, limited data management, need of considering various design aspects, utilize software tools, have multidisciplinary team involvement, and have close relationship with customers.

RQ 3: What are the important aspects to be considered for SMEs' NPD process design? Important aspects that need to be considered in SMEs' NPD process design are design activities, collaboration and source of innovation, and process modeling, tools, and techniques.

6. Future Research and Limitations

This article contributed to NPD literature on identification of topics studied in prior literature related to SMEs' NPD, characteristics of SMEs' NPD, and important aspects for the design of the NPD process. The limitation of this study is the themes of research that may not represent all the issues discussed in the articles, although obtained from the clustering based on words analysis. Therefore, we elaborate on the issues discussed within themes and present it as part of the themes. This article provides valuable insights as a starting point for future research agendas, i.e., modeling of SME's NPD process design.

There are numerous aspects of SMEs' NPD process. Investigating it from various perspectives will be a promising research opportunity. Related with design activities in NPD, research on simulation for design improvements and design evaluation approach will have substantial implications since some of the SMEs' NPD characteristics are need for adaptive, easy-to-use design methods; need technology support, and need of considering various design aspect. Research on best practices of users' consideration, lead users, and stakeholders' role in concept generation and selection will give valuable insights since external involvement and close relationship with customers is crucial in SMEs' NPD. Related with collaboration and source of innovation, research on customer's feedback and needs identification is expected to give valuable information. The emerging issues on technology-based SMEs may lead to the need of research on technology-based SMEs' NPD process. Research on technology to support open innovation may be linked to the SMEs' NPD that need technology support, and experience lack of capabilities in certain fields.

Related with process modeling, tools, and techniques, research on addressing development time acceleration and quality assurance will be promising, since SMEs experience resource limitation. It is also interesting to elaborate on tools and technique identification for SMEs' NPD process, as it is one of the considerations of designing the NPD process. Future research suggestions are listed in Table 7.

Table 7. Future research recommendation.

Topics	Example References	Future Research
Design Activities in NPD		
Simulation can support design activities	[65,77]	Simulation for design improvements
		Design evaluation approaches
Design evaluation	[71,78–81]	Best practices of user's consideration
		Lead users in SME's NPD
Users consideration and involvement in the design process	[51,57,58,82,83]	Stakeholders interaction in concept generation and selection
		Process monitoring
Collaboration and Source of Innovation		
Collaboration with customers	[87,88]	Needs identification
		Customer's feedback on product concepts
Technology's role in collaboration and innovation sourcing	[63,90]	Technology to support collaboration and open innovation
Collaboration in technology-based SME's NPD	[38,62]	NPD process in technology-based SMEs
		Team management in NPD process
Cross-functional team collaboration	[35,92–94]	Leveraging team's creativity
Process Modeling, Tools and Techniques		
Linking NPD situations with tools needed	[42,97,110]	Approach to address development time acceleration and quality assurance
Determining specific NPD process for organizations	[37,98,99]	Relevant tools and techniques identification
Challenges in implementation of tools and techniques	[61,100]	Aspects of designing NPD process
Product architecture consideration	[101–103]	Factors related with the acceptance of new tools and techniques
Acceleration of NPD process	[72,104,105]	Product architecture analysis in NPD process
Specific product requirements consideration	[56,60,76,106,107]	Integration of tools to address specific requirements into NPD process

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