REVISTA Globalización, Competitividad y Gobernabilidad | JOURNAL Globalization, Competitiveness & Governability | REVISTA Globalização, Competitividade e Governabilidade

GCG GEORGETOWN UNIVERSITY universia

Product innovation: An empirical study into the impact of simultaneous engineering on new product quality

AREA: 5
TYPE: Application

Innovación en producto: Un estudio empírico del impacto de la ingeniería simultánea sobre la calidad del nuevo producto

Inovação em produto: Um estudo empírico do impacto da engenharia simultânea sobre a qualidade do novo produto

AUTHOR
Beatriz Minguela-Rata[1]
GIPTIC-UCM
Complutense University of Madrid, Spain
minguela@ccee.ucm.es

The importance of new product development in remaining competitive, as well as of their quality as a source of competitive advantage is unquestioned. What is in doubt, however, is the traditional practice of organizing and implementing the development process because experience shows that satisfactory levels of quality are not always reached in new products. The objective of this paper is to analyze the impact of a practical alternative, simultaneous engineering (through its fundamental principles), on the increase in quality of new products.
The results appear to indicate that simultaneous engineering can account for the rise in new product quality. Early involvement is the basic principle of simultaneous engineering which has no effect on new product quality, and the use of multifunctional teams has the greatest effect on this variable representing the success of a new product.

La importancia del desarrollo de nuevos productos para seguir siendo competitivos, así como de su calidad como fuente de ventaja competitiva es incuestionable. Lo que está en duda, sin embargo, es la práctica tradicional de la organización y ejecución del proceso de desarrollo, porque la experiencia demuestra que unos niveles satisfactorios de calidad no siempre se alcanzan en los nuevos productos. El objetivo de este trabajo es analizar el impacto de una práctica, la ingeniería simultánea, (a través de sus principios fundamentales), en el aumento de la calidad de los nuevos productos. Los resultados parecen indicar que la ingeniería simultánea puede influir en el aumento de la calidad de los nuevos productos. La implicación temprana es el principio básico de la ingeniería simultánea, que no tiene ningún efecto sobre la calidad del nuevo producto, y el uso de equipos multifuncionales tiene el mayor efecto sobre esta variable que representa el éxito de un nuevo producto.

A importância do desenvolvimento de novos produtos para continuar a ser competitivos, assim como da sua qualidade como fonte de vantagem competitiva é inquestionável. O que está em dúvida, no entanto, é a prática tradicional da organização e execução do processo de desenvolvimento, porque a experiência demonstra que uns níveis de qualidade satisfatórios nem sempre se alcançam nos novos produtos. O objectivo deste trabalho é analisar o impacto de uma prática, a engenharia simultânea, (através dos seus princípios fundamentais), no aumento da qualidade dos novos produtos. Os resultados parecem indicar que a engenharia simultânea pode influenciar o aumento da qualidade dos novos produtos. O envolvimento precoce é o princípio básico da engenharia simultânea, que não tem nenhum efeito sobre a qualidade do novo produto, e, o uso de equipas multifuncionais tem o maior efeito sobre esta variável que representa o sucesso de um novo produto.

DOI 10.3232/GCG.2011.V5.N3.05
Received 02.11.2011
Accepted 12.11.2011

---

[1] Corresponding author: Departamento de Organización de Empresas; Facultad de Ciencias Económicas y Empresariales; Universidad Complutense de Madrid; Campus de Somosaguas; 28223 Madrid; Spain

1. Introduction

The design and development of new products has become an essential activity for companies wishing to remain competitive in their markets, irrespective of sector or size. But innovation alone is not enough. What really determines not only competitiveness but also survival is the speed with which companies get their products to market, how efficient production is and how well the product meets the consumer's needs.

Linked to this innovating activity is uncertainty. To tackle this, organizational structures that allow for free transmission and processing of information are needed. In reality, however, companies favor functional structures which are excessively bureaucratic. Instead of promoting the transmission and processing of information they stifle it, with the result that they are incapable of competing in a dynamic environment with increasingly higher levels of uncertainty.

For this reason, managements have for some time been rethinking their traditional approaches to developing new products, and are continuously looking out for new methods and practices of improving the organization and execution of such development processes in order to create winning products.

In traditional new product development, a sequential approach was followed in which the necessary steps in the development of a project were carried out one after the other. These steps were assigned to different functional departments who worked independently and were not linked to the other areas. It was precisely this lack of integration among functional areas that brought about a series of problems.

In order to resolve the inefficiencies resulting from the sequential approach and to develop new products successfully, new structures and processes are needed that can generate, process and transmit new ideas, knowledge and information (Sheremata, 2000), with the aim of reducing the uncertainty inherent in the development process (Minguela-Rata *et al.*, 2006). One way of achieving this is by introducing integrated methods, for example simultaneous engineering (also known as concurrent engineering). The underlying idea in this simultaneous approach is the involvement of all the departments taking part in the new product development process from the earliest stages, cooperating with each other and overlapping the different steps to be implemented in time. In this approach, each activity is begun with information from the previous step, thus achieving a reduction in development time and costs, as well as improvements in quality. According to Koufteros *et al.* (2001, 2002, 2006) simultaneous engineering is based on three fundamental principles: the use of multifunctional teams for the development of new products, concurrent workflow (i.e. overlapping execution of steps in the development process), and early involvement[1].

While many research studies have shown that simultaneous engineering has beneficial effects (Kinkel and Som, 2010) on the development of new products in terms of reductions in time (Clark and Fujimoto, 1989, 1991; Wheelwright and Clark, 1992; Clark and

Key words
New product development, simultaneous engineering, product innovation, quality

Palabras clave
Desarrollo de nuevos productos, ingeniería simultánea, calidad

Palavras-chave
Desenvolvimento de novos produtos, engenharia simultânea, qualidade

JEL Code
M110

---

[1] Other authors have described two fundamental principles of simultaneous engineering, considering that early involvement is part of concurrent workflow (see for example Minguela-Rata *et al.*, 2006).

Wheelwright, 1993; Krishnan *et al.*, 1997; Loch and Terwiesch, 1998; Terwiesch and Loch, 1999; Gerwin and Barrowman, 2002; Minguela-Rata *et al.*, 2006) and costs involved, fewer studies have focused on the influence of simultaneous engineering on the increase in product quality.

This study therefore aims to analyze the impact of simultaneous engineering (broken down into its fundamental principles) on the improvement in new product quality. The analysis is focused on the level of new product development projects, and is based on an empirical study of a particular industrial sector. We have chosen manufacturers of electronic equipment, radio, television and communications products evidencing real product innovation carried out in Spain. The study will conclude with implications for company management arising from the results obtained in the analysis.

2. Theoretical background

2.1 New product development teams

If the final aim is to develop a new product successfully, it will be necessary to carry out processes to differentiate and integrate activities. Functionally specialized departments may not be aware of mutual needs among functional areas, leading in turn to a lack of organizational integration which can hamper or indeed limit the development of new products. One way to avoid this situation would be to bring the different interdependent departments together in such a way as to ensure their effective contribution to the overall aims of the organization, thus generating greater benefits if they were to work separately (Souder and Chakrabarti, 1978; Pinto and Pinto, 1990; Griffin and Hauser, 1996; Souder *et al.*, 1998). Obviously, each functional area carries out different activities and has different responsibilities, yet all areas involved in the process of developing a new product are interdependent and interrelated. The integration of activities is therefore a necessary process in new product development, and many companies have failed in their product innovation precisely because they did not pay sufficient attention to the necessary integration processes (Millson and Wilemon, 2002; López-Sánchez *et al.*, 2006; Minguela-Rata *et al.*, 2006).

One formula which allows these tasks to be carried out, while at the same time facilitating the integration of the different functional areas, is teambuilding. Work teams are necessary elements when carrying out innovation. As Tang (1998) argues, innovative ideas generally come from an individual and are then analyzed, perfected and developed by a work team. But such a team is not just a group of individuals working together[2]. Clark and Wheelwright (1992, 1993) have identified various types of new product development teams with which the project can be organized (functional teams, matrix teams -lightweight team structure and heavyweight team structure- and autonomous teams), showing the advantages and

---

[2] The most relevant differences between work groups and teams can be found in the work of López-Sánchez *et al.* (2006).

disadvantages of each[3]. When deciding on a specific type of team, the advantages and disadvantages of each of these structures must be weighed up, as well as the features of both the project to be implemented and the context in which the development process will be carried out (McCann and Galbraith, 1981; Crawford, 1986).

In contrast to this, other writers in the literature argue that multifunctional teams are necessary in order to achieve a successful product. These teams are made up of people from different functional areas in the company and even from outside the business, such as customers and suppliers (McCann and Galbraith, 1981; Gupta and Wilemon, 1990; Clark and Wheelwright, 1992; Hauptman and Hirji, 1996, 1999; Millson and Wilemon, 2002; Leenders et al., 2003; Sarin and McDermott, 2003; Kratzer *et al.*, 2004, 2005; Büchel, 2005; Perks *et al.*, 2005; Lakemond *et al.*, 2006; Minguela-Rata *et al.*, 2006; Edmondson and Nembhrad, 2009; Schmidt *et al*., 2009; Bonner, 2010; Lau *et al.*, 2010; Fuchs and Schreier, 2011). Such teams make it possible to establish the necessary relationships between the activities of the different departments and thus reach agreement when making decisions regarding the project and share responsibilities (Pinto *et al.*, 1993; Prida-Romero and Gutiérrez-Casas, 1995; Van Der Vegt and Bunderson, 2005; Minguela-Rata *et al.*, 2006; Chen *et al*., 2008; Edmondson and Nembhard, 2009; Bstieler and Hemmert, 2010) from start to finish.

It is not necessary that the people making up the team be found in the same place of work, since the use of new computer and communication technologies make it possible for team members to interact without being present physically, thus creating virtual teams (Andres, 2002; Leenders *et al.*, 2003; Kratzer *et al.*, 2004, 2005; Meroño-Cerdán, 2005; Montoya *et al.,* 2009; Salomo *et al.*, 2010; Fuchs and Schreier, 2011). They will also be able to access a great deal of information in the company's database in a coordinated and efficient manner, such as the identified needs of customers, the feasibility of the project, its development costs, manufacturing capacity, etc. (Cordero, 1991). The productivity of such teams depends on the skill of its members in exploiting information networks and knowledge flows (Leenders *et al.*, 2003; Kratzer *et al*., 2004; López-Sánchez, 2004; Piller and Walcher, 2006; Song *et al.*, 2006; Berchicci and Tucci, 2010; Fuchs and Schreier, 2011).

These teams should have a project leader in charge of organizing, planning, directing and controlling the whole development process who should be fully dedicated to the project from start to finish (Cooper and Kleinschmidt, 1995; Cooper, 1998; McDonoughIII, 2000; Sarin and McDermott, 2003; Perks *et al.*, 2005; Wing, 2005; Minguela-Rata *et al.*, 2006; Edmondson and Nembhard, 2009; Paulsen *et al.*, 2009).

The way in which members of the team interact will have considerable influence on the success of the new product (Barczak and Wilemon, 1991; Griffin and Hauser, 1992; Souder *et al*., 1998; Millson and Wilemon, 2002; Reilly *et al*., 2002; Kratzer *et al.*, 2004; Büchel, 2005; Chen *et al.*, 2008; Berchicci and Tucci, 2010; Bstieler and Hemmert, 2010, Salomo *et al.*, 2010). For this reason it is necessary to find the right size of the team, given that the more people involved the more difficult the interaction between them will be. In some case it is easier to achieve this integration and cooperation among members in smaller teams because far fewer relationships need to be established. As the size of the team grows, the complexity of the information flows between members increases considerably, thus raising the likeli-

---

[3] López-Sánchez *et al.* (2006) have a grid summarising the advantages and disadvantages of each type of team for the development of new products.

hood of errors (Safoutin and Thurston, 1993). Therefore, a new product development project manager should try to form a team with a small number of people with necessary and complementary skills, rather than a team with more people who have limited, albeit specialized, skills (Ebadi and Utterback, 1984; Pinto and Pinto, 1990; Rosenthal, 1992; Katzenbach and Smith, 1993; Souder *et al.*, 1998; Lee *et al.*, 2000; Reilly *et al.*, 2002; Mulec and Roth, 2005; Smith *et al.*, 2005; Hoegl and Parboteeah, 2006; López-Sánchez *et al.*, 2006; Chen *et al.*, 2008).

2.2 Concurrent workflow

A second fundamental principle underlying simultaneous engineering is concurrent workflow, or in other words, the overlapping execution of activities involved in the new product development process.

New product development processes involve a set of scientific, technical, commercial and financial activities. While there are differences in the new product development processes of different companies, given that the projects have to be adapted to their environment, and that there are cultural and structural differences between companies, none of these activities should be excluded (Minguela-Rata, 2002). Traditionally, these activities have been carried out sequentially, in a structured process with clearly defined sequential stages. In these stages the product is defined, designed, transferred to the factory and brought to market (Iansiti, 1995). This process is characterized by clear separation between concept development and implementation (Biazzo, 2009). Each activity is carried out once the previous one has been completed, which results in increased development time and costs (Takeuchi and Nonaka, 1986; Cordero, 1991). This approach suffers from a lack of integration of the functional areas involved in the execution of the process. Problems with product quality can arise when decisions are taken without joint consultation in a previous stage and then have a negative influence the next (Cordero, 1991; Dobers and Söderholm, 2009).

The environment of continuous change in which companies operate has driven many to substitute the traditional approach with an overlapping or parallel method, the aim of which is to consider simultaneously all aspects necessary to the creation of the product. In this method, a different set of design principles are applied which avoid having to follow a series of hierarchical, sequential and rigidly defined stages (Iansiti, 1995). Instead, rapid and flexible interactions which generate information flows in both directions are encouraged (Hauptman and Hirji, 1996; Tatikonda and Rosenthal, 2000; Biazzo, 2009; Berchicci and Tucci, 2010). Activities overlap, i.e., each is begun using information coming from the execution of the previous step while still in operation. This cuts down on development time and means that demand can be met more quickly, thus beating competitors (Clark and Fujimoto, 1989, 1991; Wheelwright and Clark, 1992; Clark and Wheelwright, 1993; Krishnan *et al.*, 1997; Loch and Terwiesch, 1998; Terwiesch and Loch, 1999; Minguela-Rata, 2002; Haque, 2003) and satisfying customers.

2.3 Early involvement

The third component of simultaneous engineering reflects the need for all departments participating in the new product development to be involved in the initial stages of the project, and this is known as early involvement.

The early involvement of all participants in the development project (the members of the multifunctional team) means that everyone contributes their opinions and the information they have available from the very beginning. The result of this is likely to be a higher level of agreement and clarity regarding product specifications before a great deal of time and money has been spent, and before final decisions have been taken (Gupta and Wilemon, 1990). Indeed, Millson *et al.* (1992) argues that the main cause of delay in product development are orders to change engineering specifications as a result of the time wasted by functional departments in communicating among themselves because of the distance that separates them (Koufteros *et al.*, 2001).

Early involvement enables the other functional areas to know quickly whether specifications can be met, if the materials are available, whether customers are satisfied, etc. In sum, the rapid transmission of information enables engineers to start work on different stages of the problem while the design is still under development. This reduces risk and aids early detection of problems, should these arise, resulting in improvements in the quality (Fleischer and Liker, 1992; Ulrich *et al.*, 1993) and success of the finished product (Mishra *et al.*, 1996; Song and Parry, 1996; Dvir *et al.*, 2003; Haque, 2003; Bstieler, 2005; Verworn *et al*., 2008).

Nevertheless, the people who have decision making responsibilities in the early stages of the product development tend to be adverse to risk and thus typically delay final decisions for as long as possible in order to have the maximum empirical data to hand with which to check their hypotheses. On the other hand, those who have to take decisions about the design and then transform specifications into goods and services may have the same risk aversion and yet try to take decisions quickly in order to start work on firm hypotheses as soon as possible (Prida-Romero and Gutiérrez-Casas, 1995: 142).

A certain amount of controversy can be found in the literature regarding this topic. Some writers argue that early involvement is something that should be analyzed as part of multifunctional teams or concurrent workflow[4]. Indeed, as has been described above, in order to carry out the stages of a new product development process with an overlapping approach these are begun using information from previous stages. The following stages are therefore begun before the earlier stages have been completed. The underlying argument here is that the later stages need to be involved in the earlier ones (Boyle *et al.*, 2006), and some writers consider that this component is included in the concept of concurrent workflow. Furthermore, the people who have to implement the stages form part of a multifunctional team for new product development, in which the necessary integration (Boyle *et al.*, 2006) and commitment among its members must exist from the very beginning, often extending to involve suppliers and customers. For this reason, other writers consider that early involvement comes under the use of multifunctional teams for new product development.

---

[4] See for example Maylor (1997), Swink (1998), Minguela-Rata *et al.* (2006), among others.

2.4 New product quality

Growth and survival of companies will depend largely on the introduction and development of new products in the market. This however is a highly risky activity as evidenced by the high rate of failure involved[5].

The quality of the product has become a key factor through which companies can differentiate themselves from their competitors and gain competitive advantage. In order to achieve this, companies have to know what the customers' needs are for the product in terms of quality and try to meet them.

Sometimes customers are willing to pay a premium if they perceive the product is of superior quality (Koufteros *et al.*, 2001, 2006). Given the enormous range of available products with similar features therefore, and that price is generally not a key factor in the customer's purchase decision, companies must develop new products which not only meet their needs but also exceed their expectations.

The product's total quality can therefore be defined as the degree to which it satisfies or even exceeds the expectations of the consumer (Clark and Fujimoto, 1991; Fujimoto *et al.*, 1996). The development of a product with high levels of quality but of little or no value to potential customers can be avoided by focusing carefully on the consumer.

Decisions and actions regarding product features taken during its development affect the product's final quality directly, by incorporating quality attributes in the design of the new product, as well as indirectly, by designing the product in such a way as to increase the company's ability to produce the product within specification (Emmanuelides, 1993; Minguela-Rata, 2002).

Sometimes, the level of quality for a product is easily established but at the same time difficult to define, given that this is the most ambiguous of aims. Setting the quality objectives of a product at the beginning of the project provides common ground for all those involved in the design and development stages. At some point of the project, before key decisions are taken, it is important to have clear objectives or targets for each of the quality dimensions applied to the product to be developed (Rosenthal, 1992; Minguela-Rata, 2002).

Since traditional ways of developing a new product have not been particularly successful because they have caused shortcomings in terms of quality, in this paper we try to evaluate the impact of simultaneous engineering (as detailed in its three underlying principles) on the increase in quality of the new product. The focus of our study can thus be summed up in the following hypothesis:

> *Hypothesis: the greater the use of simultaneous engineering, in terms of more frequent use of multifunctional teams, higher levels of concurrent workflow and increased early involvement, the greater the rise in the new product's quality.*

---

[5] Studies carried out by Booz *et al.* (1968, 1982) show a failure rate of between 30% and 40%.

3. Research methodology

3.1 Justification of the sector, choice of population and description of the sample

In order to analyze the hypothesis, we chose a combination of businesses belonging to a single sector, with genuine product innovation carried out in Spain (while fully aware of the fact that the sector variable could distort the findings we wanted to analyze), and we focused the analysis at the level of new product development projects.

The sector chosen was the manufacture of electronic materials and equipment, and radio, television and communications equipment and apparatus (Spanish National Classification of Economic Activities: CNAE, 32). This industrial sector is in the “information technologies manufacturing firms” category according to the International Standard Industrial Classification in its third revision (ISIC Rev.3).

This is a more and more globalised industry with extremely high levels of competition, with companies needing to develop new products in order to survive. According to the OECD, this industrial sector belongs to those with a medium to high level of technological intensity. In this respect, the competitiveness of the Spanish electronics and telecommunications sector is based fundamentally on the efforts of companies in terms of Research, Development and Innovation.

When selecting companies for inclusion in the population, the database of the Centre for Industrial Technology Development (CDTI) of the Spanish Ministry of Science and Technology was consulted. This lists companies who have or have had links with the Center and can thus be considered innovators.

The next stage was to design a questionnaire (based on a review of the literature, both theoretical and empirical), using 5 point Likert scales and groups of questions referring to each of the variables under study. This was subjected to evaluation by academics and researchers in the field of innovation, as well as by two directors of the project. After the inclusion of the suggested changes, telephone contact was established with some of the technical directors of the companies in the population, who were interested in the study. The questionnaire was directed at the technical directors or R&D managers of the businesses, the people most qualified to express an opinion on the questions included.

All the questions referred to a new product developed by the company in Spain and available on the market. The respondents had firstly to identify the product in questions by name or reference code and then describe it in terms of the degree of innovation it represented for the company and the market. The empirical analysis was carried out on a sample of 43 companies in a target population of 126, representing a response rate of 34.13%. This figure falls within the range found in other Spanish studies, and can thus be considered suitable for rigorous statistical analysis, the estimated standard error of the highest population average being around 10%. Table 1 shows the distribution of responses by for regions (Spanish federal political units).

Table 1. Response distribution for regions

REGIONS	POPULATION	POPULATION %	RESPONSE	RESPONSE %	PERCENTAGE %
Andalucía	9	7.14	5	11.63	55.55
Aragon	8	6.35	5	11.63	62.5
Castilla-Leon	1	0.79	0	0	0
Catalonia	39	30.95	8	18.60	20.51
Galice	4	3.17	1	2.32	25
La Rioja	1	0.79	0	0	0
Madrid	43	34.13	16	37.21	37.21
Murcia	1	0.79	1	2.32	0
Navarra	2	1.59	2	4.64	100
Basque Country	11	8.73	3	6.98	27.27
Valence	7	5.56	2	4.65	28.57
TOTAL	**126**	**99.98**	**43**	**99.98**	**34.13**

3.2 Instruments for measuring the variables

The information gathered from the questionnaires was used to construct a set of indicators to represent the variables which were to be measured, using the arithmetic mean for this purpose.

Measuring the new product development teams

In order to measure this variable, an indicator (TEAM) was constructed, simplifying the instrument used by Minguela-Rata *et al.* (2006). Four dimensions were considered for this purpose: (1) the degree of integration of team members (Wheelwright and Clark, 1992; Katzenbach and Smith, 1993; Edmondson and Nembhard, 2009; Salomo *et al.*, 2010), (2) the characteristics of the project leader (Cooper and Kleinschmidt, 1995; Cooper, 1998; Edmondson and Nembhard, 2009; Paulsen *et al.*, 2009), (3) support from top management (Song *et al.*, 1996, 1997), and (4) the degree of multifunctionality (Teachman, 1980; Pfeffer and O'Really, 1987; Ancona and Caldwell, 1992; Edmondson and Nembhard, 2009).

While for the first three dimensions a multi-item scale was developed which covered the most relevant aspects and gave them all the same weighting, for the fourth dimension (the degree of functionality) an index of functional diversity was calculated[6] (Teachman, 1980; Pfeffer and O'Really, 1987; Ancona and Caldwell, 1992). To measure this, respondents were asked to indicate the total number of people making up the team, and then to break this number down by functional areas[7]. As the functional diversity index had values from

---

[6] $H = -\sum_{i=1}^{s} Pi(\ln Pi)$ where P represents the fraction of team members assigned to different functional areas. The higher this value, the greater the functional diversity within the team. The values obtained for this index range from 0 to 1.89.

[7] The areas covered in the questionnaire were: Engineering/R+D, marketing, finance, production, customer and/or supplier participation.

0 to 1.89, this was recalculated to transform it into a continuous item (from 1 to 5) so that all items referring to new product development teams were measured on a scale of 1 to 5.

The TEAM indicator was then calculated based on the 7 items using the arithmetic mean, since there was no a priori reason to justify a higher weighting for any of the dimensions. Cronbach's alpha was found to be 0.686.

Measurement of concurrent workflow

Based on the limited number of studies attempting to measure this variable, an indicator (CWF) was constructed consisting of 2 dimensions with which we will attempt to evaluate the degree to which companies use a sequential or overlapping approach to carry out new product development processes. These 2 dimensions focus on communications: (1) sense and use of the communication (Gupta and Wilemon, 1988a, 1988b; Clark and Fujimoto, 1989, 1991; Wheelwright and Clark, 1992; Clark and Wheelwright, 1993; Hauptman and Hirji, 1996, 1999; Minguela-Rata, 2002; Minguela-Rata *et al.*, 2006; Edmondson and Nembhard, 2009), and (2) its frequency (Pinto and Pinto, 1990; Clark and Fujimoto, 1991; Minguela-Rata, 2002; Minguela-Rata *et al.*, 2006).

To measure these aspects, we have used 5 items, with a Cronbach's alpha of 0.791. A high value for this indicator points to greater levels of concurrent workflow, which means that the company is carrying out the development process using more of an overlapping approach. In order to facilitate the overlapping of previous and following stages, frequent bilateral communication of preliminary information is recommended instead of the presentation of complete information. As a result, the dimensions used to measure concurrent workflow are related to information and the way it is transmitted.

Measuring early involvement

Bearing in mind the controversy described above among simultaneous engineering experts regarding early involvement, with some claiming that early involvement is part of the study of multifunctional teams, while others see it as part of concurrent workflow, for this study we have attempted to construct an indicator (EARLYNVL) with 5 items with which to evaluate the involvement of team members, different departments and top management from the earliest stages of the development process (Hauptman and Hirji, 1996, 1999; Koufteros *et al.*, 2001, 2002, 2006; Minguela-Rata, 2002; Minguela-Rata *et al.*, 2006).

Cronbach's alpha reached 0.699. High values for this indicator reflect a greater degree of early involvement of the participating departments in the new product development project.

Measurement of the dependent variable: product quality

Based on a review of the theoretical as well as empirical literature, a four-item indicator (QUALITY) was developed with which it is hoped to measure the degree to which the new product meets the quality specifications or targets set by the company on the one hand (Griffin and Page, 1993, 1996; Song *et al.*,1997; Minguela-Rata, 2002), and to what extent the new product satisfies the needs of the customer on the other (Voss, 1985; Pinto and Slevin, 1988; Hise *et al.*,1989; Clark and Fujimoto, 1991; Dougherty, 1992; Griffin and Page, 1993; Hultink and Robben, 1995; Fujimoto *et al.*, 1996; Filippini and Maschietto, 2000; Minguela-Rata, 2002). The latter aspect is particularly relevant when measuring quality given that it determines the capacity of the company to develop a new product which is capable of satisfying the needs of the consumer (Minguela-Rata, 2002). It was felt that both aspects were important, since, as Minguela-Rata (2002) show, quality specifications set by the company as targets to be met are not necessarily identical to customer needs or expectations. Cronbach's alpha measured 0.8150. The greater the value returned by these items, the higher the level of quality.

Control variable: degree of product innovation

There is a lack of agreement in the literature about the most suitable environment in which to apply simultaneous engineering when developing new products. Some writers recommend restricting this method to low risk environments (e.g. Cordero, 1991; Lincke, 1995; Terwiesch and Loch, 1999), since simultaneous engineering in radical innovation can generate a series of hidden costs. Attempting to carry out new product development processes in the fastest possible way causes a rise in unexpected errors and inefficiencies which in turn leads to longer development and delivery times (Crawford, 1992).

This lack of agreement seems to arise in those cases where speed to market is the most important factor, but it does not appear when we attempt to analyze the level of quality of the finished product. Nevertheless, it was decided to include the degree of product innovation as a control variable in order to check whether results might be distorted.

For this purpose, respondents are asked to describe the type of product in question in terms of the degree of originality for the company and the market. With this information, we include a dummy variable in the model (INNV) representing the type of innovation in such a way that a value of 1 indicates radical innovation -completely new products for both company and market (Booz *et al.*, 1982; Griffin, 1997; Avlonitis *et al.*, 2001; Garcia and Calantone, 2002; Minguela-Rata, 2002; Salomo *et al.*, 2007; Verworn *et al.*, 2008; Reinders *et al.*, 2010)-, while a value of 0 reflects incremental innovation -reduction of costs, repositioning in the market and product modification (Booz *et al.*, 1982; Kleinschmidt and Cooper, 1991; Ali, 1994; Griffin, 1997; Minguela-Rata, 2002; Verworn *et al.*, 2008)-. Table 2 shows the distribution of the degree of product innovation.

Table 2. Response distribution according to product innovation degree

INNOVATION DEGREE	FREQUENCY	PERCENTAGE (%)
Radical Innovation	22	51.2%
Incremental Innovation	21	48.8%
Total	**43**	**100.0%**

A description of the variables used in the study as well their typology is shown as a summary in Table 3. Having defined the variables under investigation, the model to be analyzed can be summarized in the following way:

$$QUALITY = \beta_0 + \beta_1 TEAM + \beta_2 CWF + \beta_3 EARLYNVL + \beta_4 INNV + \varepsilon$$

Table 3. Used variables

	VARIABLE	TYPE	TYPE
Teams	TEAM	Independent	Continuous (enclosed between 1 and 5)
Concurrent workflow	CWF	Independent	Continuous (enclosed between 1 and 5)
Early involvement	EARLYNVL	Independent	Continuous (enclosed between 1 and 5)
Innovation	INNV	Control	Dichotomous
Quality	QUALITY	Dependent	Continuous (enclosed between 1 and 5)

4. Results

Table 4 shows descriptive statistics for the independent and dependent variables, while the correlations between the variables in the analysis can be seen in Table 5.

Table 4. Descriptive statistics

	MEAN	MÍN.	MÁX.	STAND. DESV.
TEAM	3.81	2.71	4.76	0.48
CWF	3.55	2.00	5.00	0.74
EARLYNVL	2.94	2.20	4.60	0.61
QUALITY	4.20	3.00	5.00	0.49

Table 5. Correlations

	CWF	EARLYNVL	QUALITY
TEAM	0.527**	0.426**	0.460**
CWF		0.444**	0.485**
EARLYNVL			0.282

First of all, we have checked for possible bias in the case of no response by comparing the aspects marked by the respondents who returned the questionnaire in the first weeks with those who answered in the final weeks, but no significant differences were found.

Secondly, to check our hypothesis we ran a multiple regression analysis using the statistical package SPSS for Windows, version 15.0. The results of this can be seen in Table 6.

Table 6. Linear regression analysis

DEPENDENT VARIABLE: QUALITY (n=43)		
CONSTANT		
	β_0	2.181***
	Standard error	0.571
TEAM		
	β_1	0.334*
	Standard error	0.184
CWF		
	β_2	0.238**
	Standard error	0.113
EARLYNVL		
	β_3	-0.010
	Standard error	0.129
INNV		
	β_4	-0.110
	Standard error	0.147
Adjusted R^2		0.236
Test *F*		4.160***

*** $p \leq$ 0’01; ** $p \leq$ 0’05 ; * $p \leq$ 0’1

As test F shows, the model we posited is significant, which means it can explain variations in quality of the new products developed. It is therefore possible to reject the null hypothesis that there is no significant linear relationship between simultaneous engineering and new product quality. The correlation coefficient R^2 indicates that all the variables incorporated in the model can explain 23.6% of the variation in new product quality. We are aware that this value is not particularly high, but this due to the fact that simultaneous engineering is only being analyzed to explain new product quality. There are, however, techniques which companies can use to raise the quality which have not been considered here (as they are not relevant to the aim of the study). See for example Miranda-González and Bañegil-Palacios (2001, 2002) who have classified the methods in the literature into five groups: *design techniques, manufacturing techniques, organizational techniques, information techniques, and the participation of suppliers.*

Nevertheless, we should remember that the aim of the study, and thus its fundamental contribution, is to analyze the impact of each of the main principles underlying simultaneous engineering (multifunctional teams, concurrent workflow and early involvement) on the increase in new product quality. For this reason we must concentrate our attention on the parameters associated with each one of the independent variables representing the fundamental principles of simultaneous engineering.

We can see that not all of them are significant. The use of multifunctional teams (TEAM) does turn out to be significant, in fact it has the biggest influence on the increase of product quality, as does concurrent workflow (CWF), but the third principle, early involvement (EARLYNVL) is not significant. This is borne out by the correlation between this factor and the other two independent variables (the use of multifunctional teams, with a r = 0.426**, and concurrent workflow, with an r = 0.444**).

This result is very interesting in that it supports those researchers who claim that simultaneous engineering only has two underlying precepts (multifunctional teams and concurrent workflow). Teams made up of people from different functional areas need integration of and commitment from their members from the start, which means that early involvement is already implicit in this idea. Concurrent workflow provides a similar argument, since the overlapping execution of activities is carried out with information from previous activities, and this implies that participants in the development process are must be involved from the beginning.

With regard to the dummy variable INNV, results of the regression show a negative but not significant coefficient. This indicates that the improvement in quality of the new product is achieved independently of the degree of innovation.

The results obtained are reliable, since the residuals conform to the null hypothesis, homocedasticity and non auto-correlation, and have a normal distribution.

5. Conclusions

The importance of product quality is not any doubt today as a source of competitive advantage. Presented with a wide choice of products capable of meeting their needs, consumers relegate more traditional variables involved in purchasing decisions, such as price, to a secondary level. Instead, the customer will choose products which, while falling within their range of price and required features, best meet their needs. From a business point of view, however, the new product should not only satisfy the customers' needs but also exceed their expectations.

Experience has shown that traditional practices employed by companies to develop new products have not been efficient, preventing them from competing in dynamic environments with high degrees of uncertainty. Managements therefore had to apply new approaches to improve the organization and execution of such development processes and thus generate successful products with improved levels of quality.

The purpose of this paper, therefore, is to analyze one of these new approaches, in particular the impact of simultaneous engineering on the improvements in new product, studying each of the fundamental principles in turn: the use of multifunctional teams, concurrent workflow, and early involvement. To carry out this study, a questionnaire was designed and sent to 126 Spanish companies with innovative products, manufacturing electronic materials, radio, television and communications equipment (Spanish National Classification of Economic Activities: CNAE-32). A linear regression analysis was run on the 43 valid questionnaires returned which allowed us to evaluate the hypothesis, with the degree of improvement as the control variable.

The results of the regressions appear to indicate that, on the one hand, early involvement is the basic principle of simultaneous engineering which has no effect on new product quality, and on the other hand that the use of multifunctional teams has the greatest effect on this variable representing the success of a new product.

Such teams consist of people from different functional areas, including customers and suppliers, who cooperate in executing the tasks of the team. They have the support of top level management, a leader who is fully dedicated to the project from start to finish, and will stimulate communications and informal relations. This helps to reach agreement when taking decisions regarding the project, which in turn allows an earlier identification of problems and their solutions, given that all technical, commercial, manufacturing aspects, etc., are considered from the beginning of the project. Furthermore, taking the customers into account when shaping the development team helps the product not only to meet but also exceed their expectations, thus ensuring a high level of quality for the product.

Simultaneous engineering brings together all members of a project through a system of information and knowledge interchange, and establishes simple and effective mechanisms to coordinate activities. The early identification of problems and solutions make engineering changes necessary which will affect both previous and later stages. Nevertheless, such engineering changes to incorporate technical or market information will help to create products that will satisfy the needs of consumers and even exceed their expectations. This raises the quality of the new product independently of the degree of innovation, since we have not found empirical evidence of differences in quality between radical and incremental product innovation.

Given the available data, early involvement does not appear to be a factor that significantly affects the increase in new product quality, although this result may be due to the high correlation between this factor and the other basic principles of simultaneous engineering. Indeed, as mentioned in the theoretical background, these results support those researchers who propose only two basic principles for simultaneous engineering, since early involvement is an aspect which can be analyzed either under multifunctional teams or concurrent workflow.

Although much attention has been focused in this paper on theoretical and empirical aspects, the design of the study and the analysis of the hypothesis, there are a number of limitations which necessitate careful evaluation of the results obtained.

Firstly, the model contains subjective variables, and for this reason a questionnaire was used, despite the problem of low rates of return which is reflected in this study. Furthermore, since the information about the basic principles of simultaneous engineering as well as the dependent variable is supplied by the same person, it is possible that the study suffers from common variance bias.

Secondly, the indicators used to construct the different research variables have produced satisfactory but in our opinion not particularly high values in reliability tests. Improving these indicators in the future could perhaps provide, if not better results, at least an indication of the influence of early involvement on increases in new product quality.

A third limitation is connected with the target population of CNAE-32 sector companies manufacturing innovative products in Spain. It appears from the descriptive analysis of the questionnaire responses that these companies are still some way behind what is advocated in the literature on simultaneous engineering. This may be due to the fact that, irrespective of sector, some companies are averse to the implementation of such integrative methods because of the important changes involved in structure and organization and the way in which their processes are carried out. This factor and the first limitation pointed out above imply that care should be taken not to extrapolate the results obtained here to other sectors, to companies with innovative processes or to those which implement innovation outside Spain. In future research, apart from the improvements mentioned such as refining the indicators, we are planning to use case studies in order to collect greater amounts of data and carry out new explanatory studies.

References

Ali, A. (1994), "Pioneering versus incremental innovation: review and research propositions", Journal of Product Innovation Management, Vol. 11, pp. 46-61.

Ancona, D.G. and Caldwell, D.F. (1992), "Demography and design: predictors of new product team performance", Organization Science, Vol. 3, pp. 321-341.

Andres, H.P. (2002), "A comparison of face-to-face and virtual software development teams", Team Performance Management, Vol. 8, pp. 39-48.

Avlonitis, G.J., Papastathopoulou, P.G. and Gounaris, S.P. (2001), "An empirically-based typology of product innovativeness for new financial services: success and failure scenarios", Journal of Product Innovation Management, Vol. 18, pp. 324-342.

Barczak, G. and Wilemon, D. (1991), "Communications patterns of new product development team leaders", IEEE Transactions on Engineering Management, Vol. 38, pp. 101-109.

Berchicci, L. and Tucci, C.L. (2010), "There is more to market learning than gathering good information: the role of shared team values in radical product definition", Journal of Product Innovation Management, Vol. 27, pp. 972-990.

Biazzo, S. (2009), "Flexibility, structuration, and simultaneity in new product development", Journal of Product Innovation Management, Vol. 26, pp. 336-353.

Bonner, J.M. (2010), "Customer interactivity and new product performance: Moderating effects of product newness and product embeddedness", Industrial Marketing Management, Vol. 39, pp. 485-

Booz, Allen and Hamilton (1968), Management of new products. The Free Press, New York.

Booz, Allen and Hamilton (1982), New Products Management for the 1980s. The Free Press, New York.

Boyle, T., Kumar, V. and Kumar, U. (2006), "Determinants of integrated product development diffusion", R&D Management, Vol. 36, pp. 37-54.

Bstieler, L. (2005), "The moderating effect of environmental uncertainty on new product development and time efficiency", Journal of Product Innovation Management, Vol. 22, pp. 267-284.

Bstieler, L. and Hemmert, M. (2010), "Increasing learning and time efficiency in interorganizational new product development teams", Journal of Product Innovation Management, Vol. 27, pp. 485-499.

Büchel, B. (2005), "New product development team success: the team's knowledge network makes a real difference", Perspectives for Managers, Vol. 129, pp. 1-4.

Chen, M-H., Chang, Y-C. and Hung, S-C. (2008), "Social capital and creativity in R&D project teams", R&D Management, Vol. 38, pp. 21-34.

Clark, K.B. and Fujimoto, T. (1989), "Overlapping problem solving in product development", in Ferdows, K. (Ed.), Managing International Manufacturing, Amsterdam, North-Holland, pp. 127-152.

Clark, K.B. and Fujimoto, T. (1991), Product Development Performance: Strategy, Organization and Management in the World Auto Industry, Harvard Business School Press, Boston.

Clark, K.B. and Wheelwright, S.C. (1992), "Organizing and leading: Heavyweight developments teams", California Management Review, Vol. 34, pp. 9-28.

Clark, K.B. and Wheelwright, S.C. (1993), Managing new product and process development; text and cases, The Free Press, New York.

Cooper, R.G. (1998), "Benchmarking new product performance: results of the best practices study", European Management Journal, Vol. 16, pp. 1-17.

Cooper, R.G. and Kleinschmidt, E.J. (1995), "Performance typologies of new product projects", Industrial Marketing Management, Vol. 24, pp. 439-456.

Cordero, R. (1991), "Managing for speed to avoid product obsolescence: A survey of techniques", Journal of Product Innovation Management, Vol. 8, pp. 283-294.

Crawford, C.M. (1986), New product management, Irwin, New York.

Crawford, C.M. (1992), "The hidden costs of accelerated product development", Journal of Product Innovation Management, Vol. 9, pp. 188-199.

Dobers, P. and Söderholm, A. (2009), "Translation and inscription in development projects: Understanding environmental and health care-related organizational change", Journal of Organizational Change Management, Vol. 22, pp. 480-493.

Dougherty, D. (1992), "Interpretive barriers to successful product innovation in large firms", Organization Science, Vol. 3, pp. 179-392.

Dvir, D., Raz, T. and Shenhar, A.J. (2003), "An empirical analysis of the relationship between project planning and project success", International Journal of Project Management, Vol. 21, pp. 89-95.

Ebadi, Y.M. and Utterback, J.M. (1984), "The effects of communication on technological innovation", Management Science, Vol. 30, pp. 572-585.

Edmondson, A.C. and Nembhard, I.M. (2009), "Product development and learning in project teams: the challenges are the benefits", Journal of Product Innovation Management, Vol. 26, pp. 123-138.

Emmanuelides, P.A. (1993), "Towards an integrative framework of performance in product development projects", Journal of Engineering and Technology Management, Vol. 10, pp. 363-392

Filippini, R. and Maschietto, A. (2000), "Drivers of new product development performances. An empirical study", working paper, Universitá di Padova.

Fleischer, M . and Liker, J.K. (1992), "The hidden professionals: product designers and their impact on design quality", IEEE Transactions of Engineering Management, Vol. 39, pp. 254-264.

Fujimoto, T., Iansiti, M. and Clark, K.B. (1996), "External integration in product development", in Nishiguchi, T. (Ed.), Managing product development, Oxford University Press, New York, pp. 121-161.

Fuschs, C. and Schreier, M. (2011), "Customer empowerment in new product development", Journal of Product Innovation Management, Vol. 28, pp. 17-32.

Garcia, R. and Calantone, R. (2002), "A critical look at technological innovation typology and innovativeness terminology: a literature review", Journal of Product Innovation Management, Vol. 19, pp. 110-132.

Gerwin, D. and Barrowman, N.J. (2002), "An evaluation of research on integrated product development", Management Science, Vol. 48, pp. 938-953.

Griffin, A. (1997), "PDMA research on new product development practices: updating trends and benchmarking best practices", Journal of Product Innovation Management, Vol. 14, pp. 429-458.

Griffin, A. and Hauser, J.R. (1992), "Patterns of communication among marketing, engineering and manufacturing: a comparison between two new product teams", Management Science, Vol. 38, pp. 360-373.

Griffin, A. and Hauser, J.R. (1996), "Integrating R&D and marketing: a review and analysis of the literature", Journal of Product Innovation Management, Vol. 13, pp. 191-215.

Griffin, A. and Page, A.L. (1993), "An interim report on mesuring product development success and failure", Journal of Product Innovation Management, Vol. 10, pp. 291-308.

Griffin, A. and Page, A.L. (1996), "PDMA success measurement project: recommended measures for product development success and failure", Journal of Product Innovation Management, Vol. 13, pp. 478-496.

Gupta, A.K. and Wilemon, D.L. (1988a), "The credibility-cooperation connection at the R&D-marketing interface", Journal of Product Innovation Management, Vol. 5, pp. 20-31.

Gupta, A.K. and Wilemon, D.L. (1988b), "Why R&D resists using marketing information", Research-Technology Management, Vol. 31, pp. 36-41.

Gupta, A.K. and Wilemon, D.L. (1990), "Accelerating the development of technology based new products", California Management Review, Vol. 32, pp. 24-44.

Haque, B. (2003), "Problems in concurrent new product development: an in-depth comparative study of three companies", Integrated Manufacturing Systems, Vol. 14, pp. 191-207.

Hauptman, O. and Hirji, K.K. (1996), "The influence of process concurrency on project outcomes in product development: an empirical study of cross-functional teams", IEEE Transactions on Engineering Management, Vol. 43, pp. 153-164.

Hauptman, O. and Hirji, K.K. (1999), "Managing integration and coordination in cross-functional teams: an international study of concurrent engineering product development", R&D Management, Vol. 29, pp. 179-191.

Hayes, R.H., Wheelwright, S.C. and Clark, K. (1988), Dynamic Manufacturing, John Wiley & Sons, New York.

Hise, R.T., O'neal, L., Mcneal, U. and Parasuraman, A. (1989), "The effect of product design activities on commercial success levels of new industrial products", Journal of Product Innovation Management, Vol. 6, pp. 43-50.

Hoegl, M. and Parboteeah, K.P. (2006), "Team reflexivity in innovative projects", R&D Management, Vol. 36, pp. 113-125.

Hultink, E.J. and Robben, H.S.J. (1995), "Measuring new product success: the difference that time perspective makes", Journal of Product Innovation Management, Vol. 12, pp. 392-405.

Iansiti, M. (1995), "Shooting the rapids: Managing product development in turbulent environments", California Management Review, Vol. 38, pp. 37-58.

Katzenbach, J. R. and Smith, D.K. (1993), "The discipline of teams", Harvard Business Review, Vol. 71, pp. 111-120.

Kinkel, S. and Som, O. (2010), "Internal and external R&D collaboration as drivers of the product innovativeness of the German mechanical engineering industry", International Journal of Product Development, Vol. 12, nº 1, pp. 6-

Kleinschmidt, E.J. and Cooper, R.G. (1991), "The impact of product innovativeness on performance", Journal of Product Innovation Management, Vol. 8, pp. 295-309.

Koufteros, X.A. and Marcoulides, G.A. (2006), "Product development practices and performance: A structural equation modelling-based multi-group analysis", International Journal of Production Economics, Vol. 103, pp. 286-307.

Koufteros, X.A., Vonderembse, M. and Doll, W. (2001), "Concurrent engineering and its consequences", Journal of Operations Management, Vol. 19, pp. 97-115.

Koufteros, X.A., Vonderembse, M.A. and Doll, W.J. (2002), "Integrated product development and competitive capabilities: the effects of uncertainty, equivocality, and platform strategy", Journal of Operations Management, Vol. 20, pp. 331-355.

Kratzer, J., Leenders, R.A.J. and van Engelen, J.M.L. (2004), "A delicate managerial challenge: How cooperation and integration affect the performance of NPD team", Team Performance Management, Vol. 10, pp. 20-25

Kratzer, J., Leenders, R.A.J. and van Engelen, J.M.L. (2005), "Keeping virtual R&D teams creative", Research Technology Management, Vol. 48, pp. 13-16.

Krishnan, V., Eppinger, S.D. and Whitney, D.E. (1997), "A model-based framework to overlap product development activities", Management Science, Vol. 43, pp. 437-451.

Lakemond, N., Berggren, C. and van Weele, A. (2006), "Coordinating supplier involvement in product development projects: a differentiated coordination typology", R&D Management, Vol. 36, pp. 55-66.

Lau, A.K.W., Tang, E. and Yam, R.C.M. (2010), "Effects of supplier and customer integration on product innovation and performance: empirical evidence in Hong Kong manufacturers", Journal of Product Innovation Management, Vol. 27, pp. 761-777.

Lee, J., Lee, J. and Souder, W.E. (2000), "Differences of organizational characteristics in new product development: cross-cultural comparison of Korea and the US", Technovation, Vol. 20, pp. 497-508.

Leenders, R.A.J., van Engelen, J.M.L. and Kratzer, J. (2003), "Virtuality, communication, and new product team creativity: a social network perspective", Journal of Engineering and Technology Management, Vol. 20, pp. 69-92.

Lincke, W. (1995), Simultaneous Engineering, Hanser, Munich.

Loch, C.H. and Terwiesch, C. (1998), "Communication and uncertainty in concurrent engineering", Management Science, Vol. 44, pp. 1032-1048.

López-Sánchez, J.I. (2004), "¿Pueden las tecnologías de la información mejorar la productividad?", Universia Business Review, Vol. 1, pp. 82-95.

López-Sánchez, J.I., Minguela-Rata, B., Rodríguez-Duarte, A. and Sandulli, F.D. (2006), "Innovaciones incrementales e innovaciones radicales: un estudio de las características intrínsecas de los equipos para el desarrollo de nuevos productos", Cuaderno de Estudios Empresariales, Vol. 16, pp. 33-53.

Maylor, H. (1997), "Concurrent new product development: an empirical assessment", International Journal of Operations and Production Management, Vol. 17, pp. 1196-1214.

McCann, J. and Galbraith, J.R. (1981), "Interdepartmental relations", in Nystrom, P.C. and Starbuck, W.H. (Eds), Handbook of Organizational Design, vol. 2, Oxford University Press, pp. 60-84.

McDonoughIII, E.F. (2000), "Investigation of factors contributing to the success of cross-functional teams", Journal of Product Innovation Management, Vol. 17, pp. 221-235.

Meroño-Cerdán, A.L. (2005), "El correo electrónico en las Pymes para la comunicación y gestión del conocimiento", Universia Business Review, Vol. 5, pp. 70-79.

Millson, M.R., Raj, S.P. and Wilemon, D.A. (1992), "A survey of major approaches for accelerating new product development", Journal of Product Innovation Management, Vol. 9, pp. 53-69.

Millson, M.R. and Wilemon, D. (2002), "The impact of organizational integration and product development proficiency on market success", Industrial Marketing Management, Vol. 31, pp. 1-23.

Minguela-Rata, B. (2002), "Un análisis del enfoque adoptado en la ejecución de las actividades del proceso de desarrollo de un nuevo producto como factor determinante del aumento de su calidad", Ekonomiaz, Vol. 51, pp. 154-171.

Minguela-Rata, B., Sandulli, F.D., López-Sánchez, J.I. and Rodríguez-Duarte, A. (2006), "Effects of multifunctional new product development teams and overlapping approach on development time: An empirical study", International Journal of Business Environment, Vol. 1, pp. 234-252.

Miranda-González, F.J. and Bañegil-Palacios, T.M. (2001), "La utilización de nuevas técnicas de desarrollo de nuevos productos en las empresas españolas", Dirección y Organización, Vol. 26, pp. 42-52.

Miranda-González, F.J. and Bañegil-Palacios, T.M. (2002), "The effect of new product development techniques on new product success in Spanish firms", Industrial Marketing Management, Vol. 31, pp. 261-271.

Mishra, S., Kim, D. and Lee, D.H. (1996), "Factors affecting new product success: cross-country comparison", Journal of Product Innovation Management, Vol. 13, pp. 530-550.

Montoya, M.M., Massey, A.P., Hung, Y.C. and Crisp C.B. (2009), "Can you hear me now? Communication in virtual product development teams", Journal of Product Innovation Management, Vol. 26, pp. 139.155.

Mulec, K. and Roth, J. (2005), "Action, reflection, and learning – coaching in order to enhance the performance of drug development project management teams", R&D Management, Vol. 35, pp. 483-491.

Paulsen, N., Maldonado, D., Callan, V.J., and Ayoko, O. (2009), "Charismatic leadership, change and innovation in an R&D organization", Journal of Organizational Change Management, Vol. 22, pp. 511-523.

Perks, H., Cooper, R. and Jone, C. (2005), "Characterizing the role of design in new product development: an empirically derived taxonomy", Journal of Product Innovation Management, Vol. 22, pp. 111-127.

Pfeffer, J. and O'Really, C. (1987), "Hospital demography and turnover among nurses", Industrial Relations, Vol. 36, pp. 158-173.

Piller, F.T. and Walcher, D. (2006), "Toolkits for idea competitions: a novel method to integrate users in new product development", R&D Management, Vol. 36, pp. 307-318.

Pinto, J.K. and Slevin, D.P. (1988), "Project Success: definitions and measurement techniques", Project Management Journal, Vol. 19, pp. 67-71.

Pinto, M.B. and Pinto, J.K. (1990), "Project team communication and cross-functional cooperation in new program development", Journal of Product Innovation Management, Vol. 7, pp. 200-212.

Pinto, M.B. , Pinto, J.K. and Prescott, J.E. (1993), "Antecedents and consequences of project team cross-functional cooperation", Management Science, Vol. 39, pp. 1281-1297.

Prida, Romero, B. and Gutiérrez Casas, G. (1995), Logística de aprovisionamientos: el cambio en las relaciones proveedor-cliente, un nuevo desafío para la empresa del siglo XXI, McGraw-Hill, Madrid.

Reilly, R.R., Lynn, G.S. and Aronson, Z.H. (2002), "The role of personality in new product development team performance", Journal of Engineering and Technology Management, Vol. 19, pp. 39-58.

Reinders, M.J., Frambach, R.T. and Schoormans, J.P.L. (2010), "Using product bundling to facilitate the adoption process of radical innovations", Journal of Product Innovation Management, Vol. 27, pp. 1127-1140.

Rosenthal, S. (1992), Effective product design and development. How to cut lead time and increase customer satisfaction, Irwin, Illinois.

Safoutin, M.J. and Thurston, D.L. (1993), "A communications-based technique for interdisciplinary design team management", IEEE Transactions on Engineering Management, Vol. 40, pp. 360-372.

Salomo, S., Weise, J. and Gemünden, H.G. (2007), "NPD planning activities and innovation performance: the mediating role of process management and the moderating effect of product innovativeness", Journal of Product Innovation Management, Vol. 24, pp. 285-302.

Salomo, S., Kleinschmidt, E.J. and De Brentani, U. (2010), "Managing new product development teams in a globally dispersed NPD program", Journal of Product Innovation Management, Vol. 27, pp. 955-971.

Sarin, S. and McDermott, C. (2003), "The effect of team leader characteristics on learning, knowledge application, and performance of cross-functional new product development teams", Decision Science, Vol. 34, pp. 707-739.

Schmidt, J.B., Sarangee, K.R. and Montoya M.M. (2009), "Exploring new product development project review practices", Journal of Product Innovation Management, Vol. 26, pp. 520-535.

Sheremata, W.A. (2000), "Centrifugal and centripetal forces in radical new product development under time pressure", Academy of Management Review, Vol. 25, pp. 389-408.

Smith, K.G., Collins, C.J. and Clark, K.D. (2005), "Existing knowledge, knowledge creation capability, and the rate of new product introduction in high technology firms", Academy of Management Journal, Vol. 48, pp. 346-357.

Song, M., van der Bij, H. and Weggeman, M. (2006), "Factors for improving the level of knowledge generation in new product development", R&D Management, Vol. 36, pp. 173-187.

Song, X.M., Montoya-Weiss, M.M. and Schmidt, J.B. (1997), "Antecedents and consequences of cross-functional cooperation: a comparison of R&D, manufacturing, and marketing perspectives", Journal of Product Innovation Management, Vol. 14, pp. 35-47.

Song, X.M., Neely, S.M. and Zhao, Y. (1996), "Managing R&D-marketing integration in the new product development process", Industrial Marketing Management, Vol. 25, pp. 545-553.

Song, X.M. and Parry, M.E. (1996), "What separates Japanese new product winners from losers", Journal of Product Innovation Management, Vol. 13, pp. 422-439.

Souder, W.E. and Chakrabarti, A.K. (1978), "The R&D-Marketing interface: results from an empirical study of innovation projects", IEEE Transactions on Engineering Management, Vol. 25, pp. 88-93.

Souder, W.E., Sherman, D. and Davies-Cooper, R. (1998), "Environment uncertainty, organizational integration and new product development effectiveness: a test of contingency theory", Journal of Product Innovation Management, Vol. 15, pp. 520-533.

Swink, M.L. (1998), "A tutorial on implementing concurrent engineering in new product development programs", Journal of Operations Management, Vol. 16, pp. 103-116.

Takeuchi, H. and Nonaka, I. (1986), "The new new product development game", Harvard Business Review, Vol. 64, pp. 137-146.

Tang, H. (1998), "An integrative model of innovation in organizations", Technovation, Vol. 18, pp. 297-309.

Tatikonda, M. and Rosenthal, S.R. (2000), "Successful execution of product development projects: balancing firmness and flexibility in the innovation process", Journal of Operations Management, Vol. 18, pp. 401-425.

Teachman, J.D. (1980), "Analysis of population diversity", Sociological Methods and Research, Vol. 8, pp. 341-362.

Terwiesch, C. and Loch, C.H. (1999), "Measuring the effectiveness of overlapping development activities", Management Science, Vol. 45, pp. 455-465.

Ulrich, K., Sartorius, D., Pearson, S. and Jakiela, M. (1993), "Value of time in design-for-manufacturing decision making", Management Science, Vol. 39, pp. 429-447.

Van der Vegt, G.S. and Bunderson, J.S. (2005), "Learning and performance in multidisciplinary teams: the importante of collective team identification", Academy of Management Journal, Vol. 48, pp. 532-547.

Verworn, B., Herstatt, C. and Nagahira, A. (2008), "The fuzzy front end of Japanese new product development projects: impact on success and differences between incremental and radical projects", R&D Management, Vol. 38, pp. 1-19.

Voss, C. A. (1985), "Determinants of success in the development of application software", Journal of Product Innovation Management, Vol. 2, pp. 122-129.

Wheelwright, S.C. and Clark, K.B. (1992), "Competing through development capability in a manufacturing-based organization", Business Horizons, Vol. 35, pp. 29-43.

Wing, L.S. (2005), "Leadership in high-performance teams: a model for superior team performance", Team Performance Management, Vol. 11, pp. 4-11.