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Published in:
Proceedings of the 3rd International Conference on Research into Design - ICoRD'11

2011

Document Version:
Publisher's PDF, also known as Version of record

THE SPECIFICITIES OF RADICAL INNOVATION

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In this paper, we investigate a special case of new product development (NDP), that of radical innovation. When a company desires to go outside a current saturated market, it is necessary to offer a new product which is radically different from the competition. If successful, the offering will create a new market that the company can expect to dominate a least for a while until the competition strikes back. A radical NPD has several characteristics that are quite unique and distinct from other types of NPD. This paper aims at making a synthesis of these specificities. From this set of specificities, the ability of the current methodologies to deal with radical innovation is discussed.

Keywords: New product development, Radical innovation, Methodology.

1. INTRODUCTION

In this paper, we investigate a special case of new product development (NPD). When a company desires to go outside a current saturated market, it is necessary to offer a new product which is radically different from the competition — a *radical innovation*. If successful, the offer will create a new market that the company can expect to dominate at least for a while until the competition strikes back. A radical innovation is a specific NPD case where the market is unknown and the focus is as much on customer understanding as on the design of solutions. A radical innovation is not likely to happen often, and it is not even recommended because 1) the company will face deep, destabilising organisational and strategic changes, 2) once a new market is created the potential profits are huge and the company can capitalise on its dominant position. Radical innovation is nevertheless of great importance for a company's survival: a company takes as much risk by not radically innovating and staying in a given market as by trying to get into a new one [1]. Moreover, the reward in case of success is larger for radical innovation projects than for other NPD projects [2–4].

A radical NPD has several characteristics that are quite unique. This paper aims at making a synthesis of these specificities, and discusses the ability of current methodologies to support these activities.

Section 2 describes the fundaments of a radical innovation. The activities and organisation changes and hurdles that are specific for a radical NPD are presented in Sec. 3. From this set of specificities, the ability of current NPD methodologies to deal with radical innovation projects is discussed in Sec. 4.

2. THE FUNDAMENTS OF RADICAL INNOVATION

All NPD projects want to develop products that are differentiated from the competition (or have a lower cost). The literature on how to develop new products is abundant. Several books have made syntheses of current knowledge and presented methodologies for new product development (NPD), e.g. [5–9] in engineering design literature, or [10–12] in management literature. Nevertheless, this is often inside

Research into Design — Supporting Sustainable Product Development. *Edited by* Amaresh Chakrabarti
 :: *Published by* Research Publishing
ISBN: 978-981-08-7721-7

a defined market segment with which a company has experience. The clients are also familiar with the product type. Such examples of new products in Ulrich and Eppinger [5] are a bike suspension fork, a cordless screwdriver, in Pahl and Beitz [6], a fuel gauge, a potato harvesting machine, a tap, in Ullman [7], a bike mudguard. In the engineering design literature the "novel" part of NPD designates the introduction of new working principles and/or the combination of existing ones [2, p. 64; 4].

In a radically new product development project, there is no knowledge of the market, which needs to be defined, the company strategy must be continually aligned together with product development, deep organisational changes are necessary, and the company must think ahead to prevent the competition from responding too soon. Most of the radical innovation activities happen before the product development project starts, i.e. during product planning, a phase that has received limited attention in comparison with product development, see e.g. [5, 6]. In order to get out of a saturated market, it is necessary to find new core value drivers: value-added features that have been neglected by the current competitors, features that would interest consumers from different markets. It is also necessary to eliminate no longer interesting value drivers. A typical example is a low-cost innovative car: the Logan MCV wagon model. With fewer electronics and comfort facilities, it results in a lighter vehicle, more reliable (low failure rate) and with a challenging price.

The philosophy of value-driven NPD is thus to "play" with the core value drivers and determine which value drivers "that the industry takes for granted" should be eliminated, which can be the new value drivers, and what value the remaining value drivers should have [1, p. 29]. The term *innovation* covers the development of the quantum leap in value brought to the customer. The innovation may well not be technological. In the example of the Wii Nintendo game station, the innovations mainly lie in the family market segment with simple, interactive and entertaining games, rather than in a sophisticated technology.

Creating a completely new offering driven by the values it brings (be it new technical features, services and complementary products) is not enough. As a new market emerges, so does competition. The time-to-entry of competitors has continuously decreased [13]. It is also necessary to prevent (or at least consider) competition *during* the radical innovation process.

A radical innovation thus consists in finding a new set of core value-drivers, developing an adequate offering and sustaining the advantages of a first mover.

The term *radical innovation* has been used in several contexts, see Hacklin [14, Chapter 2]. It has been used in the context of changes in whole industries, e.g. [15], but also in the more restricted framework of a company, e.g. [16, 17]; this term is also suited for describing the type of NPD reviewed in this paper. It is important to stress that a radical innovation is not to be seen as the result of "heroic efforts" in a "megaproject" [18, pp. 67–68], but often as an iterative, incremental process; see the arguments of [1; 18, Chapter 4; 19]. The success of a radical innovation does thus not solely rely on the capacity and motivation of the project team and the leadership of management, and can be achieved by an adequate organisation and the use of a relevant set of methods.

In the introduction, it was noted that the potential reward of radical innovation was larger than that of other NPD projects. This may seem counter-intuitive given the risk taken, an argument against first movers often put forward in the literature, as noticed in [4]. Nevertheless, many empirical works have showed on the contrary that first movers are more likely to succeed than followers. For example, Agarwal [20] reports that the first entrants have the highest 12-year survival rate (55.9%) in comparison with followers, that is from 37.5% to 48.5% in the later product life cycle stages. Moreover, according to [1, pp. 188–190; 21; 22], the companies that propose such innovations can expect to remain dominant for 10–15 years.

If there are advantages to a radical innovation, there are also challenges that require specific activities and a specific organisation. These are presented in the next section.

3. SPECIFIC ACTIVITIES AND ORGANISATION OF A RADICAL INNOVATION PROJECT

Developing a breakthrough concept that will give birth to a new market, if successful, has several implications. The development process (or innovation process) of a radical innovation project presents

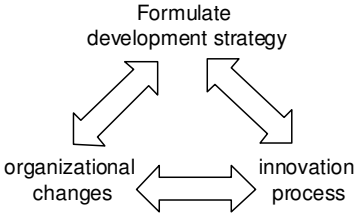

Figure 1. Aligning development, strategy and organisation.

several specificities that differentiate it from less extended development projects, as described below. As this project will re-define the company's environment and its goals, top management at the strategic level need be involved. The strategy is formulated along the definition of the value drivers and that of the solution. In a dynamic manner, top management may also adjust the solution search knowing its strategic implications. Finally, organisational changes and their related problems are to be expected. All three, development, strategy formulation and organisation changes interact (Figure 1).

In this section, the innovation process activities are presented grouped by function. Several functions are always involved: marketing, engineering design, production, finances… [23]. We will focus primarily on marketing and engineering design. Section 3.3 will present the organisational aspects and Sec. 3.4 the strategic aspects.

3.1. Marketing

An initial challenge is to reason about the different possible segmentations of the future market. The customer base is not known and needs to be built. Moreover, conventional market segmentation methods are based on industries or branches (often named after a product or service type, like boat building), customer size, customer purchase behaviour and customer location [24, pp. 48–49]. It is difficult to use these categories to determine the common benefits sought by (and the costs ready to commit) different clients across different segments.

The marketing activities during development consist not only in understanding customers, their needs (that is, marketing research) and pricing. It consists also in determining a distribution and sales system, developing a promotion strategy, that is, communicating the offering the right way, developing customer relationships….

For innovative products, it is necessary to determine the propensity of potential customers to adopt the product and to develop an appropriate communication plan [25], to estimate the market growth, to elaborate defence strategies against potential new entrants (see Hauser *et al*. [17]'s review of marketing for innovation projects). It is also necessary to predict future needs, so that future launches and improvements can be planned in advance in the company's product development programme.

3.2. Engineering design

For most engineering design process models, design starts with, or shortly after, the task clarification stage, see e.g. [5–9]. A task has been given to the design engineers who clarify it by deriving a list of specifications, and for which they find the most interesting solution principle by systematic search (e.g. [6]). The product planning phase, or fuzzy front end [18], which is generally considered outside the design process (see [5; 6, p. 64], with the noteworthy exception of Olsson [23, 26]), consists in the product idea gathering, exploitation and selection. This phase (in this form or another, see below) is on the contrary crucial for innovations.

It is necessary to determine the perimeter of the search of ideas, which requires together with marketing, determining the different usages and needs one wants to cover. The company must not restrict itself to the use of its technologies and the competencies its employees master [2], which are brakes to innovations. It is thus necessary to quickly gain in competency on diverse technical

knowledge that can solve the design problem derived from the extern analysis. The focus is on getting the right knowledge and on transforming it and using it in different solution principles. This competency and knowledge growth takes time: it is not possible to systematically search for an exhaustive set of technical solutions; on the contrary, it is only necessary to find satisfactory ones [27, 28]. On the other hand, this necessity of locating the right knowledge and the time it takes to integrate it implies that the design engineers focus on what is crucial: the most important design problems, or the design problems presenting a large risk of technical failure. The design activity is most often "depth-first" rather than "breadth-first". The study of feasibility, or *proof of concept*, is fundamental.

It is also common to benchmark existing products in order to compare them and develop a product of superior value. Benchmarking is problematic in this case because there is no single product to compare to, but a multitude. Moreover, benchmarking loses a bit of substance here: on one hand, the products compared to may well have superior technical performances for some functions, but the point of an innovative product is not to gain value on better performance, but on different functions: the performance comparison is irrelevant; on the other hand, the target customer segment is different, and thus the product-to-be is likely to have superior value in any case.

The value-added product does not consist only of a physical good, but also of associated services and every element for which the customer values the offer (trust in the company, image of the company….). In that sense, the design of the offer must go beyond engineering design activities. The different value-added elements of the offers must amount to a *proof of value*, that is, show that the proposal has a high added value for the target customers.

It is necessary, in radical innovation, to show a *proof of innovation*. It is necessary to show that there is a large differentiation with the existing products so that a new market is really created.

As mentioned above, the company must sustain its dominant position. For that, the new versions, the derivates or by-products that will complement the first offering must be determined during the development of the radical innovation [29].

3.3. Strategy formulation

Defining the corporate strategy consists in defining the company for tomorrow and checking whether it is fit for today. There can be different types of strategy, but generally a company will have a general vision, or general goal, of what it is heading to so as to be able to undertake actions to achieve it. Strategy is also determining a unique position so that the company is sustainable by selling unique products that find customers [30] and is not threatened constantly by competition. This position must of course comply with the company vision. The corollary is also that the company must decide what *not* to do [30]. When a company sells different lines of products, different strategies can be developed at the level of each business unit. The corporate strategy is important for the company as well as for the stakeholders external to it: investors and partners want to know where the company is heading and whether it does it efficiently. Within a radical innovation project, that is, the whole company strategy will need substantial changes. For a less innovative project, it is on the contrary the company strategy that constrains its scope.

Top management must lead and follow a radical innovation project and develop an adequate strategy in an interactive manner throughout the project development. It must see to the relevance of the vision that is being built, consider the impact on the company image, and on the company's and existing products' brand. It is also necessary to make the current project fit within the company's existing activities, for example the other business units, and consider possibilities for synergies among them. Of importance is the fact that the new project, if wrongly oriented, may cannibalise the company's existing and planned products. The product policy and portfolio must be efficiently managed.

Note that a company can also be completely flexible and jump on every opportunity, but even there, the top management must monitor the project advance and its impact for the whole company.

3.4. Organisation

3.4.1. Organisational changes

In the systematic search for new values, marketing and engineering must work hand in hand. It is not possible to define a set of values without any idea of possible solutions, and any technical solution may have an impact on the customer perception of the offering that marketing needs to assess. This integration has a positive impact on successful next-generation product developments [29]. See also [31] for a review.

It is also necessary to have efficient technical knowledge and competence management. This means that the research activities (testing hypotheses and gaining technical knowledge) must be linked tightly with the engineering design activities (transforming this acquired knowledge into solution principles) [32]. Even within the engineering design team, it will be necessary to put effort into idea and knowledge communication, especially as some members may be new to the team, so that every team member can integrate it into her/his own work.

Such projects have a high probability of failure. This is not necessarily a technical one: as the project progresses knowledge is accumulated, and the original opportunity may not be as promising as was thought. Several projects are likely to run simultaneously, which requires an effort in the planning and assessment of projects [33].

3.4.2. Organisational hurdles

Such a breakthrough project requires significant political, operational, and cultural changes. According to Kim and Mauborgne [1], the managers will face four key hurdles. One is cognitive: the employees need a shift of mind; they are going from a fierce but known territory (similar needs, similar techniques….) to a new one. Linked to that is the problem of motivation. The third hurdle is limited resources, and the fourth is politics: each department and division may use these changes for its own profit to the detriment of a global project success.

A radical innovation project is unlikely to be completely developed in-house. New partnerships are created, networks are developed. The necessity of building trust relationships and determining the product ownership is crucial in the context of a virtual or extended enterprise.

Even inside the engineering design teams, trust building is important. The members may not know each other, come from different backgrounds and sometimes from different companies.

3.5. Summary

The main specificities of a radical innovation are summarized Table 1.

Table 1. Specific activities and organisation of a radical innovation project.

	Specificities
Marketing	enable product adoption, communication of the value of the offering estimate the market growth, elaborate defence strategies against potential new entrants predict the future needs and usages
Design	go beyond known technologies and existing competencies get the right knowledge in a limited time find satisfacing solutions proof of concept, proof of value, proof of innovation service development determine new versions, derivates and by-products
Strategy	Continuous strategy formulation: positioning of the company, determination of what not to do, attention to investments product image, impacts on brands fit the radical innovation with the company's other activities
Organization	organizational hurdles team building, trust building partnership building, networking tight link between Research, Design and Marketing

4. ADEQUACY OF THE CURRENT DESIGN AND DEVELOPMENT METHODOLOGIES

As reviewed in [34] and in [35], the funnel development model is one of the most archetypical development models [33]. It roughly consists in 1) a product planning phase, or fuzzy front end, where the technological risks and market risks are assessed, and the major strategic decisions are taken, and 2) a product development phase where "routine" product development takes place. The design and development process is in the form of stages and gates where development and reviews are alternated [36]. In the engineering design literature, it is completed with the systematic engineering design process model (see e.g. [5–8]).

Some of the elements presented above exist in those methodologies: The funnel development process has been developed for NPD, and Wheelwright and Clark [33] propose that strategic formulation, and market feasibility (market growth estimates), be in the product planning phase. Pahl and Beitz [6], Ulrich and Eppinger [5], and others, emphasize the search for solutions beyond known technologies and existing competencies. This is one of the bases behind the development of design catalogues [37]. The development of derivates to the core product (the innovative offering), in order to ensure a constant stream of variants and complementary products, is behind the concept of *breakthrough* or radical development projects in Wheelwright and Clark [33]. The product adoption issue, or "consumer innovativeness" [17], the search for new needs, although not present in our literature, belongs to the basics of marketing [25]. Value-driven product development has been present in the form of functional analysis and value analysis methods, and now under the term value management or value engineering [38, 39]. The methods and scope may differ — the function and value analyses have been primarily developed for the improvement of existing products — but the philosophy of locating value drivers and prioritizing them is similar. The marketing textbooks consider products both as services and as goods, thus drawing attention to the latter.

On the other hand, some elements are not present or have not been prioritized in those methodologies. Searching for new technologies and working principles is emphasized, but the concept of proof (it works) is neglected to the detriment of the proof of value (the chosen concept satisfies some needs better than others). The proof of value itself is seen as static: the requirements are presented at the beginning the product development project, after the product planning phase. In a radical innovation, the determination of the customer-sought benefits that need to be fulfilled in a concept is a fundamental task. Unfortunately, this task is often put in the infamous fuzzy front end, for which design engineers have few tools and methods (recall that the conceptual design phase starts with the product development phase).

The proof of innovation is also neglected. Benchmarking is a proposed method to determine how the new product will outperform the existing ones [5], not how much it must differentiate from those in terms of new value drivers.

The proof of concept may imply advanced knowledge of diverse technologies. This technical feasibility is also presented during the product planning phase, apart from the conceptual design. Technical feasibility requires tight cooperation with the research department, which is usually not described in the literature. Any work from the research department is generally presented as prior to any development (e.g. [5, 33]).

Radical innovations projects are unlikely to happen in-house. The multiple partnerships that are required need to be managed, and trust needs to be built, at the top level as well as at the operational level. This is also fundamental for such a project, but support methods for such management activities are not prioritized in our product development literature.

Most methods used in design have been defined for the development of technical systems (TS). With services assuming more and more importance, these methods show their limits. Services are likely to be developed by other people than design engineers, but they are tightly related to the TS. In a more general manner, services must be taken into account while investigating the usages of the customers. These methods have also been built around the principle that only one product is developed at a time. In radical innovation projects, new versions, derivates and by-products must be determined

in parallel. This activity is partially in the field of product architecture, but the methods developed there do not work for complementary products.

Organisational hurdles are going to systematically happen. This is also a neglected aspect of current methodologies. The impact of a development at the strategic level is also investigated during the product planning phase. But the market is not known and will probably remain so until the product is launched: it is difficult to elaborate a market strategy. There are technology maturity problems, and some technologies will be abandoned during development; it is difficult to determine at an early stage which technologies the company should develop in-house so as to acquire a core competency, which ones should be outsourced, etc. It is difficult to predict well in advance whether a new line of products will be derived from the effort, and how this will impact the other activities of the company. The strategic aspects will be present throughout the development.

5. CONCLUSION

This paper has presented a set of specific activities as well as organizational aspects linked to radical innovation. Some specificities are already addressed in the current methodologies, but others are not. Future research within this area will include the gathering and proposal of tools and methods that tackle the specificities of radical innovation projects.

The organisation and structure of a radical innovation project is peculiar: organisational changes, development process and strategy formulation go hand in hand. Thus the separation into product planning and product development, recurring in most methodologies, may not be the best framework for radical innovations. Beyond patching the current methodologies with some complementary tools and methods, it may be necessary to re-think their structure. It is important to present the elements above in an integrated and flexible manner.

This paper has focused on the radical innovation moment itself, but two more moments require attention: the preparation before a radical innovation and the aftermath. Seizing a radical innovation opportunity is the result of proficiency and "luck" [40]. Proficiency is all the elements leading to and enabling the discovery of any event (the luck part) that can lead to an opportunity. It includes technological foresight, business intelligence, market research, knowledge re-use, and design skills. In case of market failure, a radical innovation can be transformed into a positive outcome if the knowledge is capitalized on and re-used in the company's existing and future product lines [41]. In case of success, it is necessary to continuously innovate [42]. These moments need to be integrated in a general product development methodology.

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