Electronic new product development — a conceptual framework

Jie Yang
College of Business Administration, University of Southern Mississippi, Gulf Coast, Long Beach, MS
Liming Yu
Business School, Fudan University, Shanghai, PR China

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Knowledge management, New product development

Abstract
Today's knowledge economy era is characterized by short product life-cycles, dynamic customer requirements and complex business processes, knowledge management (KM) is becoming the pivot of new product development. In this article, the interactions between five activities of KM and new product development process are discussed in detail. Then, a novel concept – electronic new product development (E-NPD) is put forward. E-NPD is defined as the convergence of customer relationship, business processes, enterprise IT applications, and knowledge management system necessary to perform continuous innovation through new business model in the new knowledge-based economy. Based on a case study in the high-tech industry, we demonstrate that the convergence of KM and new product development have greatly enhanced the efficiency of new product development, accordingly led to the success of new product. In the end, it is concluded that competence of NPD is from KM by describing the E-NPD structure as an organism.

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In an increasingly competitive global environment, successful firms must be able to expand their knowledge base and develop new skills. Firms that fail to realize this are being left behind. History shows that the leading firms in one generation are rarely the leading firms in the next. In order to maintain existing competitive advantage, firms must focus on Total Customer Orientation, the Network-Centric Enterprise, the Virtual and Agile Enterprise, and the Knowledge-based Enterprise. All of these are greatly related to knowledge management (KM). In the past decade, the rapid rate of technology development, change of customer's needs, shortened product life cycles, integration of global markets pose a tremendous challenge to NPD processes. KM has been well examined in the business press, but its convergence with new product development (NPD) are much less understood and appreciated.

Knowledge management, new product development and their process

KM is about accessing and using all information within an organization, enabling individuals to apply relevant information whenever and wherever it is in need, in order to create knowledge and fulfil organizational objectives. KM concerns people and the processes they use to share information and build knowledge (Hanley, 1999). The process of KM (Figure 1) consists of five activities including knowledge acquisition, innovation, protection, integration and dissemination.

NPD process may be viewed as a series of activities, including idea generation, product development and product commercialization. In a prior study, Urban and Hauser (1993) proposes that the NPD process consists of five groups of activities: opportunity identification and screening, product design, testing, commercialization, and post-launch control. But, some scholars suggested that the NPD process has been characterized as consisting of marketing and technical activities (Cooper and Kleinschmidt, 1986; Crawford, 1994). Cooper and Kleinschmidt (1986) developed a framework of the NPD process consisting of 12 activities: six marketing activities and six technical activities. Actually, all of these are consistent with perspective of Handfield *et al.* (1999), which views the NPD process as a series of interdependent and often overlapping activities, during which a new product is brought from the "idea" stage to preparation for full-scale production or service delivery. The whole process is shown in Figure 2. As the product concept moves through these stages, the product design is done, prototyping and testing are finished, and preparations for full-scale operations are finalized.

In our thinking, KM is a framework within which the organization views all its processes as knowledge processes. In this view, we assume that NPD processes are related to the KM. The interaction between them is depicted in Figure 3.

Impact of knowledge acquisition on NPD

Organizations acquire knowledge through two processes: one is searching and the other is organizational learning. Prior study (Song and Parry, 1997) suggests that a high level of cross-functional integration and learning can be realized by promoting "exploring" or "importing". R&D team have a better understanding about consumers and related competitive market through constant visiting or communicating with their major customers and conducting market research as well as by involving marketing people in the process of NPD. Learning is critical in

NPD because innovation reaches many functions including engineering, marketing, manufacturing, finance, etc., and new product team members come from different backgrounds and perspectives.

Impact of knowledge innovation on NPD

Lester (1998) demonstrates that attractive new product concept is one of the critical success factors for NPD. Idea generation requires in-depth knowledge and experience in a particular technology and market. Generating good ideas that go beyond existing company technologies and market applications will require either organizational learning or the leveraging of skills outside the company. All of these call for knowledge innovation. There are two dimensions of knowledge innovation. One dimension is the conversion of tacit knowledge to explicit knowledge, a key process in creating new knowledge. Polanyi (1962) regards tacit knowledge as the knowledge that cannot be explicated fully even by an expert and can be transferred from one person to another only through a long process of apprenticeship. But, explicit knowledge can be easily acquired through documentations and standard operations, and then shared with others easily. In an organization, tangible knowledge is in the form of job procedures as well as the company's philosophy, culture, and strategy. Knowledge-creating entities including individual, group, and organization are another dimension. These entities play a crucial role in knowledge innovation.

NPD is a complex innovation process, requiring the use of tacit and explicit knowledge in order to create and apply something that is new. We will discuss two types of innovation, both contribute to the success of NPD. According to Hage (1998), product innovation is a new technology transformed from tacit knowledge to explicit knowledge or combination of technologies which actually is a process from explicit knowledge to explicit knowledge. This idea enables people to distinguish both among the innovative patterns of firms of an industry at the same time and among those of a given firm at different times. Product innovations are concerned with the utilization of tacit knowledge for creation and application of new technology. A product innovation can be a process innovation. Organizational innovations cope with application of new administrative methods and management systems, new patterns of human interaction. In sum, we can consider innovation two types: product innovation and organizational innovation. In fact, we can see knowledge innovation as the core activity of NPD, as is illustrated in Figure 4.

Figure 1
Knowledge management process

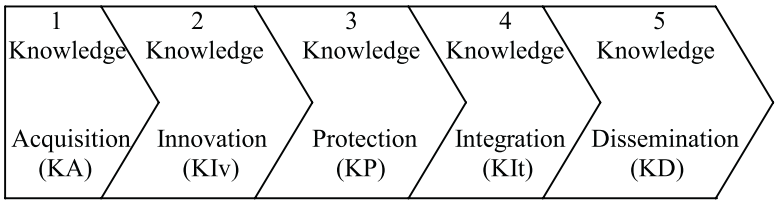


Figure 3
The interaction between KM and NPD

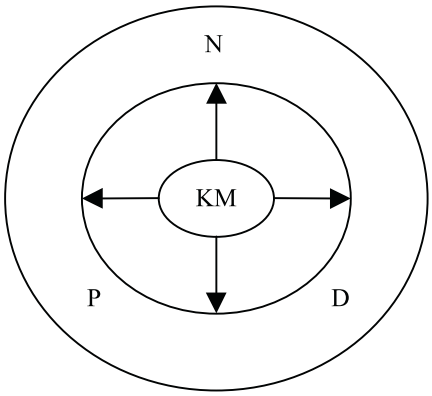
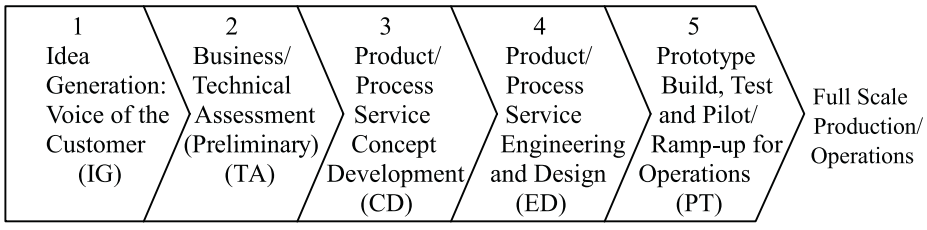
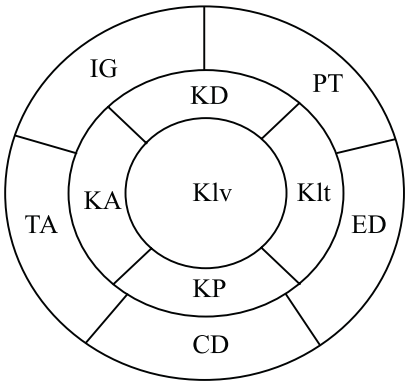


Figure 2
New product development process (Handfield *et al.*, 1999)



Source: Handfield *et al.* (1999)

Figure 4
Knowledge innovation is the core activity of NPD



Impact of knowledge protection on NPD

Knowledge protection is playing an increasing role while it gets involved up front in NPD. To be effective, proper controls need to be established before a new product appears in market. Today, information security will become a major management concern as firms depend more on electronic data transmission. Information security will become more involved in data communication authentication and encryption when new product development is based on network.

Products can be viewed as carriers of knowledge. Firms and their R&D staff put their knowledge in their products. Thus, a lot of firms analyze the products of their competitors in order to obtain their design methods and production knowledge. There are two carriers of knowledge: human and material. In organizations, there is a combination of human and material carriers of knowledge. Managers and employers and firms' management information system, documentation, machines, and other production tools. The organization can be viewed as a very complex carrier of knowledge, every combination of different knowledge carriers is possible and can be found. Knowledge protection is important because it protects creativity of workers and the interests of knowledge-owners, i.e. the innovator of new products. Many companies are tending to protect their intellectual assets using an insurance policy and regards it as part of any research and development budget. The outcome of R&D represents the success of company. If there is no strict protection measures, the outcome maybe never belong to the company and never win out of the competitive market.

Impact of knowledge integration on NPD

Knowledge and information that are related to the process of NPD should be recognized and integrated. As firms have recognized the importance of improving the core NPD process, they tend to focus on the information of both "upstream" and "downstream" of the NPD process in order to get overall required knowledge whenever and wherever it is in need. Knowledge integration within the organization can be regarded as the process of translating the raw knowledge into actionable knowledge by means of a discerning understanding in the business context.

As to customer integration involving NPD process, R&D and marketing have been one field of integration. Integration can make any organizational mechanism operation much more effective for knowledge sharing. NPD is a process of trying something that is new, which requires ventures into unfamiliar territory where new knowledge is sought. The key of such knowledge searching and sharing relies on high level of integration between R&D and marketing.

Successful supplier integration endeavors result in a major change to the new product development process. According to Handfield *et al.* (1999), there are two major factors that should be considered in deciding when to integrate the supplier into the product development processes: the rate of change of the technology and the level of supplier expertise in the given technology. If the technology is undergoing a significant technological change, it should be delayed in the product development cycle. A firm's organizational structure has to be matched with appropriate integrated and combined capabilities in order to integrate component knowledge into useful knowledge which can consequently serve as a platform for generating a new knowledge combination for NPD.

Impact of knowledge dissemination on NPD

Unlike most assets, organizational knowledge can actually grow then be disseminated and shared. When knowledge is disseminated and shared within an organization, it can be amplified and modified.

Knowledge dissemination occurs through both formal and informal communication channels between individuals and groups. These various channels help to disseminate

knowledge and provide a platform for transforming individual knowledge to organizational knowledge. Although formal channels for transfer are associated with explicit knowledge, they will be most effective as a means of disseminating tacit knowledge as long as the tacit knowledge can be accessed. As people interact through the various relationships and communication ways, the interactions become larger in scale and faster in speed when more and more individuals are involved in the organization. Actually, this is a spiral of organizational knowledge creation. In the spiral, knowledge begins at the individual level, moves upwards to the group level, and then to the firm level. As the knowledge spirals upward in the organization, it may be improved and integrated as individuals interact with each other within the organization. Accompany with this spiral, a knowledge-sharing culture is created at the same time. A strong knowledge-sharing culture can enable a firm to be a leading knowledge company. This culture can become a catalyst for the company's development of knowledge-intensive new products.

KM process and its products act as the facilitators of NPD

Davenport and Prussak (1993) suggest that innovation and speed to launch products to market that are essential for business success will become increasingly critical in the future. According to Quinn *et al.* (1996), the intangible assets that add most value to these activities are knowledge-centric assets.

From Table I, we can see the intellectual capital is greatly emphasized, especially tacit knowledge, that resides in the heads of employees, plays an important role in knowledge economy. All of these require an effective KM system to support the impending need of knowledge in the NPD process.

Several researchers have described NPD as a knowledge-intensive activity (Eder, 1997; Iansiti and MacCormack, 1997; Nonaka and Takeuchi, 1995; Song and Montoya-Weiss, 1998). As products and technologies are becoming increasingly complicated, NPD requires effective tacit knowledge as well as explicit knowledge. Knowledge innovation also results in new software designed to facilitate the process of NPD. Software is designed to improve business process, coordinate communication between team members. The use of software helps the firm meet such process objectives as speed to market, reducing costs of development, and improving quality of the product.

Table I
The contrast of traditional and knowledge economy

Traditional economy	Knowledge-based economy
Manufacture	Service
Labor	Brainpower
Hardware	Software
Tangible	Intangible
Efficiency	Innovation
Management	Leadership

Knowledge acquisition, protection, integration, and dissemination lead to the coordination of organization and the exploration of network potentials. Team-based structures have been a major form in NPD project, since teams are believed to increase individual commitment and performance. Most product development projects also require the participation of many experts from cross-functional departments with various backgrounds. Internet has been imposing a significant impact on NPD, which is reflected in identifying lead user communities, involving them in the NPD process, conducting online research project and building an "Intranet" connection widely accessed by team members and other related workers. In addition, newsgroups and forums are now becoming part of the product development process.

The KM perspective of NPD also raises some significant issues about the optimal way of organizing the NPD effort, especially in a global context. During the past few years, there has been a trend toward creating virtual NPD teams which consist of people from different locations, or even countries.

When KM and NPD converge, the e-NPD emerges

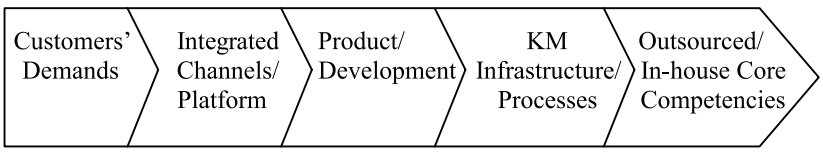
It has been widely discussed that knowledge is a critical corporate asset and its creation is essential and crucial for corporate survival. However, because knowledge is intangible, its management is not an easy task, it is indeed a great managerial challenge. Prior literature (Subramaniam and Rosenthal, 1998) indicates that NPD process requiring tacit knowledge flowing across borders that adopt cross-country teams and overseas subsidiaries as sources for new product plans, will tend to out-perform those who do not. Gupta *et al.* (1986) suggests that R&D and marketing need to be involved in all stages of the new product process to establish sustainable customer relationship and

enhance customer satisfaction. As discussed above about KM and NPD, we define electronic new product development (E-NPD) as the convergence of customer relationship, business processes, enterprise IT applications, and KM system necessary to perform continuous innovation and develop new quality products in an efficient way. The process of E-NPD is described as shown in Figure 5.

NPD was considered an independent and separate activity in the past years, it is now managed as a business process which is tightly linked with all other activities of the value chain. A crucial characteristic of this view of NPD in the new firms is that it is the requirement to create core knowledge repositories and the information interdependency between all components of the value chain. A creative view within an organization now is that it emphasizes on the crucial role of core knowledge in NPD and critical information interdependencies between business processes. Internet can speed the direct connection between firms and customers. The interaction helps firms develop close relationships with customers, major customer problems can be therefore identified through customers' feedback. This real-time precious information from customers enables new product development process to be more successful. Furthermore, it facilitates a crucial KM goal: enable team members to capture ideas, documents and discussions effortlessly and store them so that they can be reused later. This vision has now become reality, which is "E-NPD". It is important to recognize that IT alone does not guarantee effective collaboration and communication. Actually, much manual work must be done to supplement the IT implementation so as to provide the collaborative and integrated information necessary for goal achievement.

E-NPD will bring together leading practitioners and managers to explore the collaboration among organizational structure, customer relationship, and IT application. It will emphasize on how to perfect leverage the value of information and knowledge existing in an organization. E-NPD allows a faster information transfer that is difficult to be achieved in a traditional way. In traditional view, KM is overlooked in NPD process and always viewed as a separate business process. Companies that are successful at NPD have been demonstrated to put more resources on KM process as it can create major value for the organization in terms of acquiring knowledge, managing knowledge and establishing competitive advantage.

Figure 5
E-NPD process



Methodology

Case study is described by Yin (1994) as an empirical exploration that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly apparent and it relies on multiple sources of evidence. Darke *et al.* (1998) suggest that statistical summary is not the goal of case study, but the deep insight into dynamics and mechanism of processes and situations is. For these reasons, we believe that our use of case study is appropriate as it provides deep insights into KM-related problems.

Developing an E-NPD model: a case study

Companies should focus on innovative NPD process and utilizing the knowledge of their employees to improve the performance of NPD. The big problem is that organizations view their processes as separate tasks, rather than interdependent ones. Organizational structures may create obstacles in the process flow and account for knowledge gaps. Filling in the knowledge gaps will lead to better solutions to the problem. Effectively leveraging and managing knowledge requires us to overcome obstacles created due to legacy system and organizational structure and therefore build up a knowledge-sharing environment in which knowledge sharing and collaboration become necessary in doing business. So why do we still find it so difficult to apply? We can get the answer from the Acer case.

In the case of the Acer, the theme of E-NPD is being applied. To start the case study, we had better review the Internet Organizational (iO) structure of Acer Group first. iO looks like a web rather than traditional hierarchy. As of today, there are

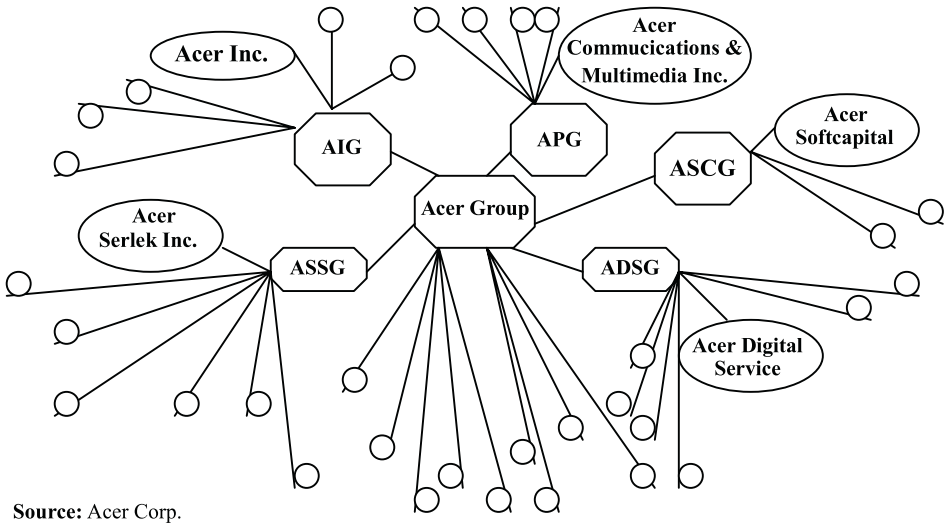
more than 30 independent business units under five sub-groups in Acer (see Figure 6). Acer's business units are connected and integrated into a whole one so as to compete in competitive high-tech market. Among the units, there are only simple and executable protocols, which are set by an Internet Organisational Protocol (iOP) committee. The iOP committee members, including five sub-group CEOs, approve and enforce the protocols on behalf of all business units.

In the knowledge era, functional and matrix organization are not as appropriate and effective for firms as they worked before. iO is put forward by Stan Shih, Chairman of the Acer Group (www.acer.com.tw), as a new business model for leading various individual business units, which are usually linked directly or indirectly in some ways and still operated independently. By means of iOP, the organization member companies operate their businesses independently and take advantage of the synergies of the strategic alliance among the units. Once the protocols within the organization are established, the organization can effectively manage and integrate all core intangible and intellectual assets and maximize the competitiveness of the whole organization. Every unit can create its own high value with a great deal of outstanding innovation or specialized knowledge within its organization. Meanwhile, every unit in an iO can share with each other in accumulating and integrating the whole group's knowledge. Acer developed the iO for the management and development of Acer's global businesses for the new knowledge-based economy, and provides a basis for Acer to perform its new product development. An iO approach offers organizations better ways to utilize the knowledge of their employees to develop competitive new products.

Successful NPD is highly dependent on effective corporation structure. In the iO structure of Acer, the principle of knowledge sharing is established through a number of structured methods. The iOP make information flows more efficient. Many different units and functional departments are now involved and eager to talk to others so as to share knowledge and such flows needed to be managed for greatest effectiveness. Marketing and NPD teams meet regularly and extensively use Internet, intranet, e-mail, direct telephone links, and video conferencing. Such an approach of E-NPD has resulted in both tangible and soft achievements. The mission of the NPD team includes developing, innovating, and selecting new technologies, as well as the traditional product development activities. An NPD team consists of a cross-functional, cross-divisional, cross-company product development team for a specific project. In this case, NPD team members actually represent the entire organization, and the knowledge of an NPD team incorporates the integrated knowledge residing in the entire business chain. E-NPD is carried out without space limitation, achieving distance virtual NPD.

There are two advantages of the E-NPD in Acer's iO organization: superior interpretation of customer requirements and broad dissemination of organizational

Figure 6
iO structure of Acer



Source: Acer Corp.

knowledge. Superior interpretation of customer requirements has the feature of understanding and translating of customer requirements. The interpretation involves customers, who are a source of articulated needs, and a developer, or supplier, whose ideas meet these needs. Interpreting customer needs and then selecting technologies to satisfy those needs is increasingly becoming a major task of the NPD team as they apply greatly supply chain management methods.

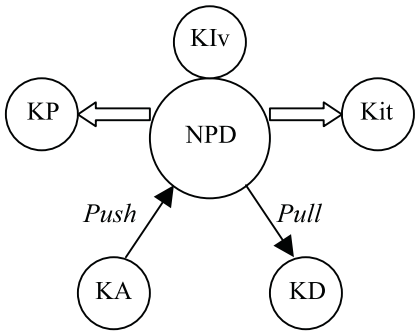
Another important advantage of the E-NPD is its superior knowledge dissemination capability. The knowledge dissemination discusses how acquired knowledge is disseminated within the organization. Unfortunately, traditional NPD teams do not learn well from product development experience. By E-NPD, knowledge is available across NPD teams and different departments and units. Since NPD members come from cross-functional departments and units, knowledge gets disseminated and coordinated during product development in iO organization.

Conclusions and managerial implications

E-NPD provides a cross-functional model for NPD by focusing on innovation and organizational learning. The primary benefit of the E-NPD is leveraging experiences and application of its knowledge to current NPD projects. In summary, we can conclude that the competence of NPD is from KM; as can be acknowledged by humanizing the interaction between KM and NPD in Figure 7. We should not look at it only as a figure, but also as a humanoid.

Obviously, we can see a person standing in front of us. Centralizing on NPD, the person has his organs perfectly with knowledge innovation as his head, knowledge protection and integration as his two arms, knowledge acquisition and dissemination as his two legs. One leg, named knowledge acquisition, acts as the back leg pushing the NPD process forward; the other leg, knowledge dissemination, acts as the foreleg pulling NPD process. The pushing and pulling forces form a knowledge chain with inlet and outlet imposing him going ahead. That is, E-NPD has been driven by the push of knowledge acquisition and the pull of knowledge dissemination, which is organizational need to make employees knowledgeable and develop a competitive new product. The push-pull forces, arising from the disparities between existing knowledge repository and the knowledge organizations, need to develop new product, are the initial impetus for E-NPD. One arm, knowledge protection, protects the person from illegal invading; the other arm, knowledge integration, assists the person to become more skilful. Certainly, knowledge innovation, as the head of the person, plays the most important role in the movement. It acts as the function of the brain, providing the person with new ideas and new thoughts to make him smart and creative, so that he can win the competitive advantage out of intensive competition, as is the object of E-NPD.

Figure 7
E-NPD as an organism



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