Modified stage-gate: A conceptual model of virtual product development process

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Review

Modified stage-gate: A conceptual model of virtual product development process

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In today's dynamic marketplace, manufacturing companies are under strong pressure to introduce new products for long-term survival with their competitors. Nevertheless, every company cannot cope up progressively or immediately with the market requirements due to knowledge dynamics being experienced in the competitive milieu. Increased competition and reduced product life cycles put force upon companies to develop new products faster. In response to these pressing needs, there should be some new approach compatible in flexible circumstances. This paper presents a solution based on the popular Stage-Gate system, which is closely linked with virtual team approach. Virtual teams can provide a platform to advance the knowledge-base in a company and thus to reduce time-to-market. This article introduces conceptual product development architecture under a virtual team umbrella. The paper describes all the major aspects of new product development (NPD), NPD process and its relationship with virtual teams, Stage-Gate system finally presents a modified Stage-Gate system to cope up with the changing needs. It also provides the guidelines for the successful implementation of virtual teams in new product development.

Key words: Modified stage-gate system, virtual product development, conceptual model.

INTRODUCTION

New product development (NPD) is widely recognized as a key to corporate prosperity (Lam et al., 2007). Different products may require different processes, a new product idea needs to be conceived, selected, developed, tested and launched to the market (Martinez-Sanchez et al., 2006). The specialized skills and talents required for the development of new products often reside (and develop) locally in pockets of excellence around the company or even around the world. Firms, therefore, have no choice but to disperse their new product units to access such dispersed knowledge and skills (Kratzer et al., 2005). As a result, firms are finding that internal development of all technology needed for new products and processes are difficult or impossible. They must increasingly acquire technology from external sources (Stock and Tatikonda, 2004).

Virtualization in NPD has recently started to make serious headway due to developments in technology – virtuality in NPD is now technically possible (Leenders et al., 2003). Automotive OEMs (Original equipment manufacturers) have formed partnerships with suppliers to take advantage of their technological expertise in development, design, and manufacturing (Wagner and Hoegl, 2006). As product development becomes the more complex, supply chain also have to collaborate more closely than in the past. These kinds of collaborations almost always involve individuals from different locations, so virtual team working supported by IT, offers considerable potential benefits (Anderson et al., 2007). May and Carter (2001) in their case study of virtual teams working in the European automotive industry have shown that enhanced communication and collaboration between geographically distributed engineers at automotive manufacturer and supplier sites make them get benefits in terms of better quality, reduced costs and a reduction in the time-to-market (between 20 - 50%) for a new product vehicle.

Although the uses of the internet in NPD have received considerable attention in the literature, very little is written about the collaborative tool and virtual team implementtation in NPD. On the other hand, Stage-Gate system which defines different steps of product development has

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some criticism and according to the extent of information and communication technology (ICT) need to modify. In forthcoming section the major aspects of new product development (NPD), NPD process and its relationship with virtual teams, Stage-Gate system and finally presents a modified Stage-Gate system will be described.

NEW PRODUCT DEVELOPMENT (NPD) CALLS FOR VIRTUALITY

Product development definition used by different researchers in slightly different ways, but generally it is the process that covers product design, production system design and product introduction processes and start of production (Johansen, 2005). A multidisciplinary approach is needed to be successful in launching new products and managing daily operations (Flores, 2006). In the NPD context, teams developing new products in the turbulent environments encounter quick depreciation of technology and market knowledge due to rapidly changing customer needs, wants, and desires (Akgun et al., 2007). Adoption of collaborative engineering tools and technology (e.g., Web-based development systems for virtual team coordination) was significantly correlated with NPD profitability (Ettlie and Elsenbach, 2007). ICT enhances the NPD process by shortening distances and saving on costs and time (Vilaseca-Requena et al., 2007).

Kafouros et al. (2008) found that internationalization enhances a firm's capacity to improve performance through innovation. Since efficiency, effectiveness and innovation management has different and contradictory natures, it is very difficult to achieve an efficient and innovative network cooperative NPD (Chen et al., 2008b). Supplier involvement in NPD can also help the buying firm to gain new competencies, share risks, move faster into new markets, and conserve resources (Wagner and Hoegl, 2006).

New product development (NPD) has long been recognised as one of the corporate core functions (Huang et al., 2004). During the past 25 years NPD has increasingly been recognized as a critical factor in ensuring the continued existence of firms (Biemans, 2003). The rate of market growth and technological changes has accelerated in the past years and this turbulent environment requires new methods and techniques to bring successful new products to the marketplace (González and Palacios, 2002). Particularly for companies with short product life cycles, it is important to quickly and safely develop new products and new product platforms that fulfil reasonable demands on quality, performance, and cost (Ottosson, 2004). The world market requires short product development times (Starbek and Grum, 2002), and therefore, in order to successfully and efficiently get all the experience needed in developing new products and services, more and more organizations are forced to move from traditional face-to-face teams to virtual teams or adopt a combination between the two types of teams (Precup et al., 2006).

Given the complexities involved in organizing face-to-face interactions among team members and the advancements in electronic communication technologies, firms are turning toward employing virtual NPD teams (Jacobsa et al., 2005; Badrinarayanan and Arnett, 2008; Schmidt et al., 2001). IT improves NPD flexibility (Durmusoglu and Calantone, 2006). New product development requires the collaboration of new product team members both within and outside the firm (Martinez-Sanchez et al., 2006; McDonough et al., 2001; Ozer, 2000) and NPD teams are necessary in all businesses (Leenders et al., 2003). In addition, the pressure of globalize competition forces companies to face increased pressures to build critical mass, reach new markets, and plug skill gaps. Therefore, NPD efforts are increasingly being pursued across multiple nations through all forms of organizational arrangements (Cummings and Teng, 2003). Given the resulting differences in time zones and physical distances in such efforts, virtual NPD projects are receiving increasing attention (McDonough et al., 2001). The use of virtual teams for new product development is rapidly growing and organizations can be dependent on it to sustain competitive advantage (Taifi, 2007).

New product development process

New business formation activities vary in complexity and formality from day-to-day entrepreneurial or customer prospecting activities to highly structured approaches to new product development (Davis and Sun, 2006). Today's uncertain and dynamic environment presents a fundamental challenge to the new product development process of the future (MacCormack et al., 2001). New product development is a multi-dimensional process and involves multiple activities (Ozer, 2000). Kusar et al. (2004) summarized different stage of new product development which in earlier stages, the objective is to make a preliminary market, business, and technical assessment, whereas at the later stages they propose to actually design and develop the product(s).

- Definition of goals (goals of the product development process)
- Feasibility study (term plan, financial plan, pre-calculation, goals of market)
- Development (first draft and structure of the product, first draft of components, product planning and its control processes)
- Design (design of components, drawing of parts, bills of material)

Stage-gate system in NPD: Several authors proposed different conceptual models for the NPD process, beginning from the idea screening and ending with the

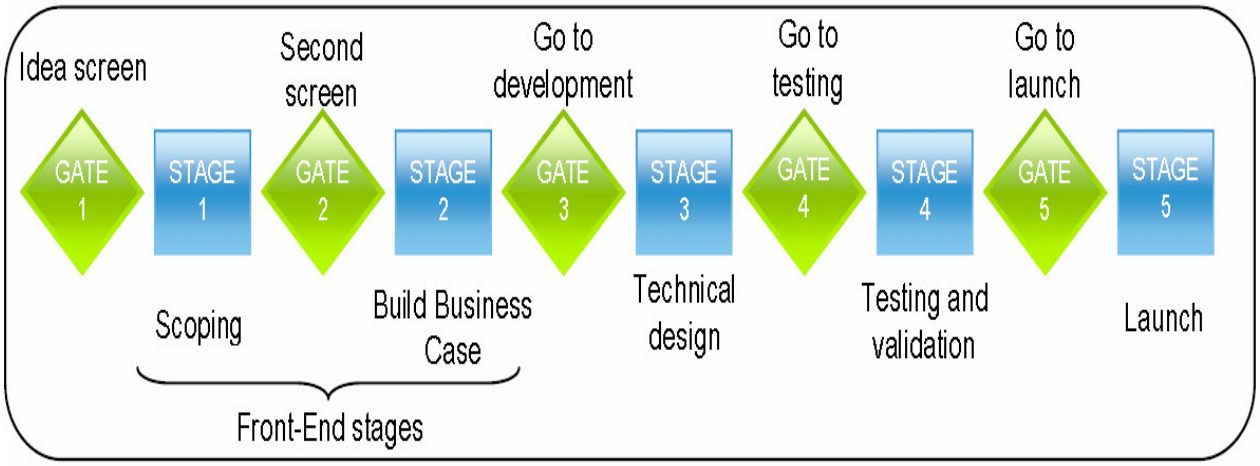

Figure 1. The stage-gate system model (source: Cooper, 2006).

commercial launching. The model of Cooper, called the Stage-Gate System is one of the most widely acknowledged systems (Rejeb et al., 2008). The Stage-Gate System model (Figure 1) divides the NPD into discrete stages, typically five stages. Each Stage gathers a set of activities to be done by a multifunctional project team. To enter into each stage, some conditions and criteria have to be fulfilled. These are specified in the Gates. A Gate is a project review in which all the information is confronted by the whole team. Some criticism of the method has surfaced, claiming that the steering group assessment in the stage and gate steps halts the project for an unnecessarily long time, making the process abrupt and discontinuous (Ottosson, 2004). A closer integration of management through virtual team in the process might be a solution for avoiding such situations.

Stage-gate process: This process is a method of managing the new product development process to increase the probability of launching new products quickly and successfully. The process provides a blueprint to move projects through the various stages of development: 1.) idea generation, 2.) preliminary investigation, 3.) business case preparation, 4.) product development, 5.) product testing, and 6.) product introduction. This process is used by such companies as IBM, Procter and Gamble, 3 M, General Motors, and others. The process is primarily used in the development of specific commercial products, and is more likely to be used in platform projects than in derivative projects.

Auto companies that have modified their Stage-Gates procedures are also significantly more likely to report (1) use of virtual teams; (2) adoption of collaborative and virtual new product development software supporting tools; (3) having formalized strategies in place specifically to guide the new product development process; and (4) having adopted structured processes used to guide the new product development process (Ettlie and Elsenbach, 2007).

DEMAND FOR MODIFIED STAGE-GATE WITH VIRTUAL PRODUCT DEVELOPMENT TEAM

Recently, the Stage-Gate system had been modified and adjusted to fitting the real situation in nowadays, called the Next Generation Stage-Gate (Figure 2). The greatest change in Stage-Gate system is that it has become a scalable process, scaled to fit very different types and risk-levels of projects, from very risky and complex platform developments through to lower risk extensions and modifications, and even to handle rather simple sales force requests.

Managers recognized that any kinds of product development project have to manage risks and consumption of resources, but it is not all necessary to go through the fulfil five-stage process. The process has revised into multiple versions to fit business needs and to accelerate projects. Stage-Gate XPress for projects of moderate risk, such as improvements, modifications and extensions; and Stage-Gate Lite for very small projects, such as simple customer requests (Cooper, 2008). Although Next Generation Stage-Gate has defined for different types and risk-levels of projects, but still team collaboration in each stage is unveiled. So dealing with virtual teams can bring an opportunity to make closer integration of team members in the process.

Virtual product development team by using collaborative tools can effectively be used both in the earlier and later stages of the NPD process. Past research has mainly focused on the role of Internet in NPD (Ozer, 2004). Almeida and Miguel (2007) have been identified in the literature that it seems to exist a lack of a conceptual model that represents all dimensions and interactions in the new product development process. On the other hand, some criticism of Stage-Gate method has surfaced, claiming that the steering group assessment in the gate

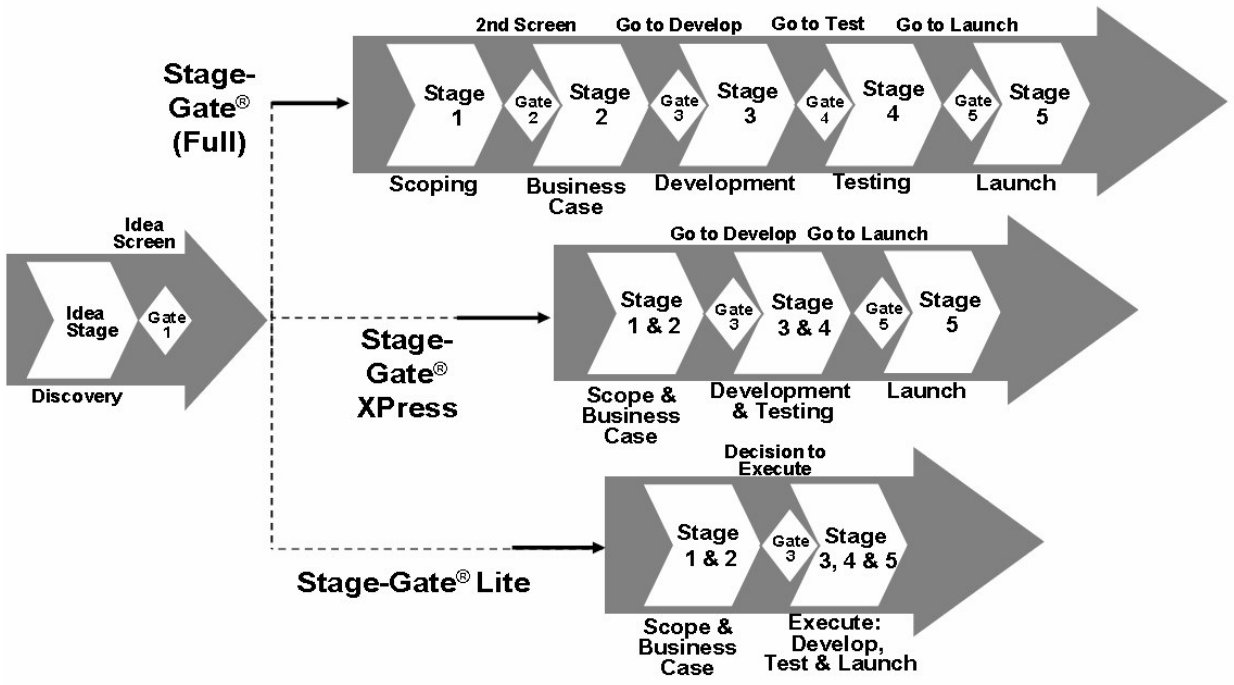

Figure 2. An overview of the next generation stag-gate (Source: (Cooper, 2008)).

step halts the project for an unnecessarily long time, making the process abrupt and discontinuous (Ottosson, 2004). A closer integration of management through virtual team in the process might be a solution for avoiding such situations. Integration is the essence of the concurrent product design and development activity in many organizations (Pawar and Sharifi, 1997). Ragatz et al. (2002) suggest that integration of the supplier's technology roadmaps into the development cycle is critical to ensuring that target costs are met.

To compensate for the lack of a conceptual model that represents all aspects and interactions in the new product process and decrease criticism of Stage-Gate system, a solution called Modified Stage-Gate system is introduced.

Figure 3 illustrates new model architecture of the virtual product development process. The architecture is structured in a two-layered framework: Traditional Stage-Gate system and collaborative tool layer which are supported by virtual team. Merge of Stage-gate system with virtual product development team lead to increased new product performance and decreased time-to-market. The following sections will describe some elements of the collaborative tool layer in more detail.

Gassmann and Von Zedtwitz (2003) defined "virtual team as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across links strengthened by information, communication, and transport technologies." Another definition suggests that virtual teams are distributed work teams whose members are geographically dispersed and coordinate their work predominantly with electronic information and communication technologies (e-mail, video-conferencing, telephone, etc.) (Hertel et al., 2005). We define, virtual team is small temporary groups of geographically, organizationally and/or time dispersed knowledge workers who coordinate their work, predominantly with electronic information and communication technologies in order to accomplish one or more organization tasks.

Capturing customer requirements

Collaborative tools allow firms to respond quickly to specific customer requirements with new, high-quality, innovative products, and it enables firms to build cross-functional competencies, enhance flexibility and share knowledge (Mulebeke and Zheng, 2006). Capturing customer requirements is represented throughout product development will facilitate performing quality function deployment (Rodriguez and Al-Ashaab, 2005).

Collaborative capabilities

Enabling collaborative capability through virtual teamwork represents a fundamental transitioning to be more effective organizational work practices (Susman et al., 2003). The use of virtual teams will change the communication pattern both within and outside the firm. Successful collaborations require more than the mere use of electronic communication and involve new skills and a supportive context that provides commitment and resources to facili-

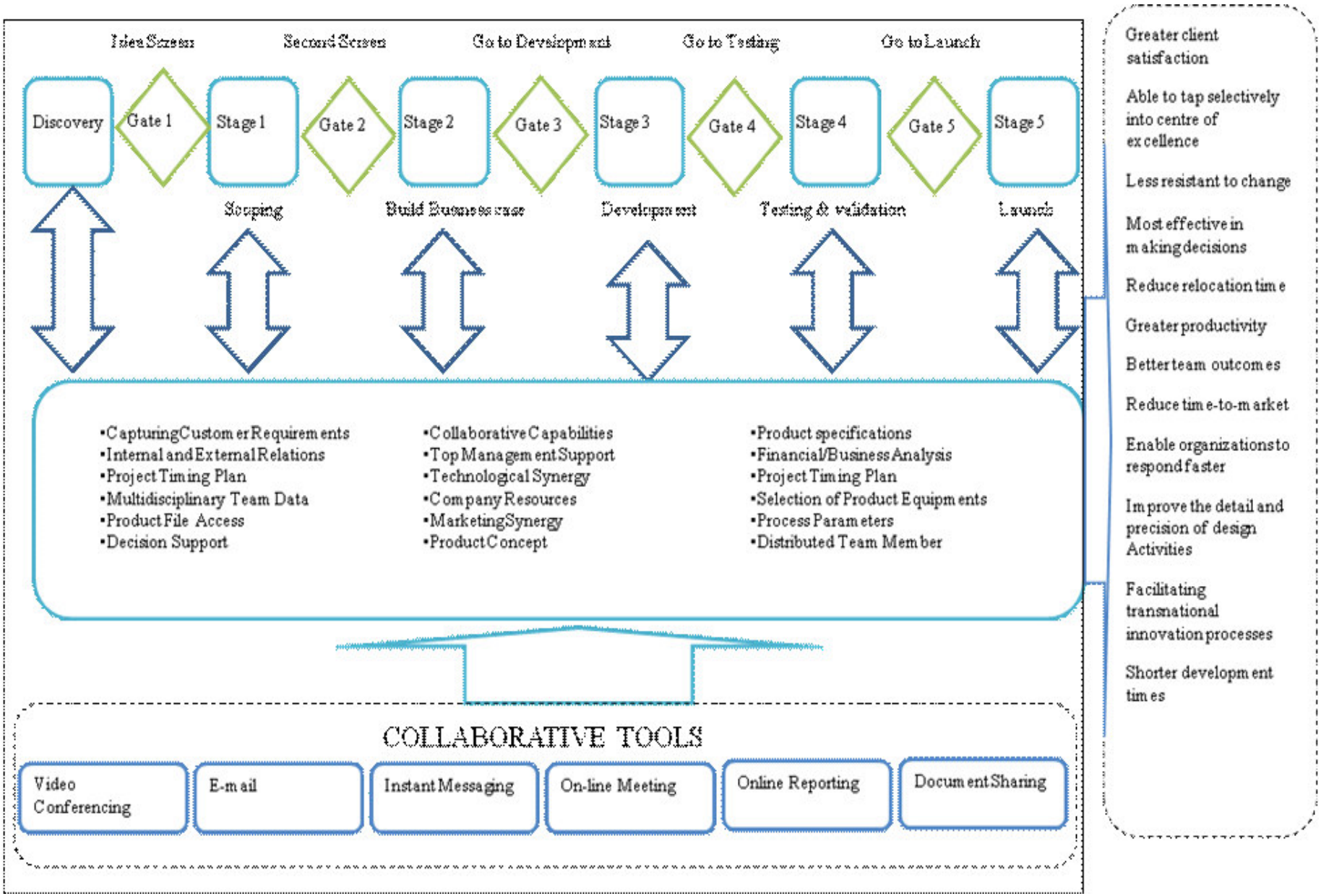

Figure 3. Modified stage-gate: model architecture of the virtual product development process.

tate collaboration (Martinez-Sanchez et al., 2006).

Company resources

Virtual team provides cost savings to employees by eliminating time-consuming commutes to central offices and offers employees more flexibility to co-ordinate their work and family responsibilities (Johnson et al., 2001). Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli et al., 2004) and able to digitally or electronically unite experts in highly specialized fields working at great distances from each other (Rosen et al., 2007).

Top management support is a strong motivational factor in the entire new product process. Although collaborative tools are able to assist top management but many managers are uncomfortable with the concept of a virtual team because successful management of virtual teams may require new methods of supervision (Jarvenpaa and Leidner, 1999). Management commitment provides organizational support for change, generates enthusiasm, provides a clear vision of the product concept and assures sufficient allocation of resources (González and Palacios, 2002).

Information sharing has been identified as an important success factor in NPD (Ozer, 2006). The positive impact of information sharing on the success of new products has long been established in the NPD literature (Sridhar et al., 2007; Furst et al., 2004; Merali and Davies, 2001; Lipnack and Stamps, 2000).

Virtual teams reduce time-to-market (Sorli et al., 2006; Kankanhalli et al., 2006; Chen, 2008; Shachaf, 2008; Ge and Hu, 2008; Guniš et al., 2007). Lead time or time to market has been generally admitted to being one of the most important keys for success in manufacturing companies (Sorli et al., 2006). Time also has an almost 1:1 correlation with cost, so cost will likewise be reduced if the time-to market is quicker (Rabelo and Jr., 2005). Virtual teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli et al., 2004) and reducing relocation time and costs, reduced travel costs (Bergiel et al., 2008; Fuller et al., 2006; Kankanhalli et al., 2006; Olson-Buchanan et al., 2007). Virtual NPD teams overcome the limitations of time, space, and organizational affiliation that traditional teams face (Piccoli et al., 2004). Virtual R&D team is able to tap selectively into a centre of excellence, using the best talent regardless of location (Criscuolo, 2005; Samarah et al., 2007; Fuller et al., 2006; Badrinarayanan and Arnett, 2008; Furst et al., 2004).

Virtual team also, respond quickly to changing business environments (Bergiel et al., 2008; Mulebeke and Zheng, 2006), able to digitally or electronically unite experts in highly specialized fields working at great distances from each other (Rosen et al., 2007), more effective R&D continuation decisions (Cummings and Teng, 2003; Schmidt et al., 2001), most effective in making decisions (Hossain and Wigand, 2004; Paul et al., 2004), provide greater degree of freedom to individuals involved with the development project (Ojasalo, 2008; Badrinarayanan and Arnett, 2008; Prasad and Akhilesh, 2002), Greater productivity, shorter development times (McDonough et al., 2001; Mulebeke and Zheng, 2006), Producing better outcomes and attract better employees, Generate the greatest competitive advantage from limited resources (Martins et al., 2004; Chen et al., 2008c; Rice et al., 2007), Useful for projects that require cross-functional or cross boundary skilled inputs (Lee-Kelley and Sankey, 2008), Less resistant to change (Precup et al., 2006), Facilitating transnational innovation processes (Gassmann and Von Zedtwitz, 2003; Prasad and Akhilesh, 2002), higher degree of cohesion (Teams can be organized whether or not members are in proximity to one another) (Kratzer et al., 2005, Cascio, 2000; Gaudes et al., 2007), Evolving organizations from production-oriented to service/information-oriented (Johnson et al., 2001; Precup et al., 2006) and provide organizations with unprecedented level of flexibility and responsiveness (Hunsaker and Hunsaker, 2008; Chen, 2008; Pihkala et al., 1999; Liu and Liu, 2007). Beside these advantages virtual NPD teams are self-assessed performance and high performance (Chudoba et al., 2005; Poehler and Schumacher, 2007), employees perform their work without concern of space or time constraints (Lurey and Raisinghani, 2001), optimize the contributions of individual members toward the completion of business tasks and organizational goal (Samarah et al., 2007), reduce the pollution (Johnson et al., 2001), manage the development and commercialization tasks quite well (Chesbrough and Teece, 2002), Improve communication and coordination, and encourage the mutual sharing of inter-organizational resources and competencies (Chen et al., 2008a), employees can more easily accommodate both personal and professional lives (Cascio, 2000), cultivating and managing creativity (Leenders et al., 2003; Atuahene-Gima, 2003; Badrinarayanan and Arnett, 2008), facilitate knowledge capture and sharing knowledge, experiences (Rosen et al., 2007; Zakaria et al., 2004; Furst et al., 2004; Sridhar et al., 2007), Improve the detail and precision of design activities (Vaccaro et al., 2008), Provide a vehicle for global collaboration and coordination of R&D-related activities (Paul et al., 2005), Allow organizations to access the most qualified individuals for a particular job regardless of their location (Hunsaker and Hunsaker, 2008) and Enable organiza-tions to respond faster to increased competition (Hunsaker and Hunsaker, 2008; Pauleen, 2003).

The ratio of virtual R&D member publications exceeded from co-located publications (Ahuja et al., 2003) and the extent of informal exchange of information is minimal (Pawar and Sharifi, 1997, Schmidt et al., 2001). Virtual teams have better team outcomes (quality, productivity, and satisfaction) (Gaudes et al., 2007; Ortiz de Guinea et al., 2005; Piccoli et al., 2004), Reduce training expenses, Faster Learning (Pena-Mora et al., 2000, Atuahene-Gima,

2003; Badrinarayanan and Arnett, 2008) and finally greater client satisfaction (Jain and Sobek, 2006).

KEY FACTORS FOR SUCCESSFULLY IMPLEMENTING VIRTUAL TEAM IN NPD

NPD is continuing to be an area that is receiving increased attention, both in practice and academic spheres (Shani et al., 2003). Eppinger and Chitkara (2006) studied global product development (GPD) base on virtual teams, for companies in the manufacturing sector by conducting interviews with 30 executives and surveying over 1150 product development executives and professionals from large manufacturing companies. They reported the following ten key success factors for successful GPD:

- Management priority and commitment – Commitment from management to make the necessary organization, process and cultural changes to make GPD work.
- Process modularity for global distribution – Ability to separate activities into modular work packages for global distribution.
- Product modularity to develop subsystems or components in different locations – Ability to break down into subsystems for global distribution.
- Core competence so the company does not become completely reliant on suppliers or contractors – Good understanding of what the company's core competencies are, so that do not get outsourced.
- Intellectual property, which becomes more difficult to protect – Defining process and products in a modular way to protect IP.
- Data quality, which concerns availability, accessibility, and audit ability – Ability to update and share data with teams in multiple locations.
- Infrastructure (including networks and power supplies) to support activities in all locations – Unified infrastructure, systems, technologies, and processes that are shared between all locations.
- Governance and product management is needed to coordinate and monitor the entire effort – Ability to coordinate and monitor program, including detailed project planning.
- Collaborative culture is necessary and is helped by a consistent set of processes and standards – Building and sustaining trust, ensuring teams have consistent processes and standards.
- Organization change management requires planning, training, and education of those in key roles for global product development plan and train for new roles, behaviours, and skills.

Conclusion

The internet, incorporating computers and multimedia, have provided tremendous potential for remote integration and collaboration in business and manufacturing applications. Most companies today are divided in different departments located in different geographical places and dealing with specialized tasks. So using collaborative tools enables authorized users in geographically dispersed locations to have access to the company's product data and carry out product development work simultaneously and collaboratively on any operating systems.

The modified Stage-Gate system has demonstrated to be a good development platform for the NPD. In order to integrate and share the information and knowledge available within geographically distributed companies, this model can be a reference model. The proposed model architecture of a virtual product development process, does not aim to replace the existing systems in companies but rather to be a support tool for communicating and sharing knowledge among the disperse partners. Modified Stage-Gate system will lead to the production of better and more cost effective products, developed in a shorter period of time.

In highly competitive era which forces companies to launch a new product faster, the decision on setting up virtual teams and using a modified NPD process is not a choice but a requirement. The theme of virtual teams and application of a collaborative tool in NPD has not been much explored and researchers in this field are encouraging more studies and analyses to be made.

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