MIS Quarterly

ISSUES AND OPINIONS

INFORMATION SYSTEMS AS A REFERENCE DISCIPLINE FOR NEW PRODUCT DEVELOPMENT[1]

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Abstract

Baskerville and Myers (2002) recently suggested that the information systems (IS) field has "come of age" and that it can now serve as a reference discipline for other fields. In this article, the discourse about their vision is extended by considering the potential for the IS field to contribute to new product development (NPD) research. It is argued that the rapid infusion of information technology (IT) along four dimensions of product development—process management, project management, information and knowledge management, and collaboration and communication—raises several important NPD research issues. These issues could be addressed by drawing from extant theories and models in the IS field. By employing NPD as the context, other issues that underlie the new role envisioned for the IS field are also identified.

Keywords: IS research issues, reference discipline, new product development, IT infusion, diffusion of research, knowledge network, IS research agenda

ISRL Categories: AI03, AI05, IB03, IB04, ID05

Introduction

Baskerville and Myers (2002) recently advanced the vision of the *information systems (IS) field as a reference discipline,* because it is increasingly better placed to contribute to research in related fields. Although the authors acknowledge the potential difficulties in realizing their vision, they also emphasize the utility of the vision as a rhetorical device. It could be used to provoke debate and discussion on (1) the need to adopt a wider perspective in the conduct and communication of IS research, and (2) the future growth and evolution of the IS discipline.

This article seeks to further extend the above discourse. Specifically, the objective is to demon-

[1]Ron Weber was the accepting senior editor for this paper.

strate how the IS field can serve as a reference discipline for the field of new product development (NPD). Given the interdisciplinary nature of NPD research, as well as the recent rapid infusion of information technology (IT) in product development, the NPD field is an appropriate context in which to identify and discuss important issues that underlie the new role envisioned for IS.

This article begins by briefly considering the general motivations, qualifications, and implications of the emerging role of IS as a reference discipline. Next, the gradual evolution of the NPD field is traced and the increasing infusion of IT in NPD activities identified. The nature of this IT infusion is then examined and it is argued that the NPD field promises to be a rich application area for IS theories. The ensuing NPD research issues and potential IS contributions are identified. The paper concludes by highlighting key lessons from other NPD reference disciplines.

Information Systems as a Reference Discipline

To understand the motivations, qualifications, and implications of the IS field assuming the role of a reference discipline, Baskerville and Myers (2002) suggest the notion of a knowledge-creation network. Within this network, different fields engage in intellectual discourse that involves the exchange of ideas. Such a perspective implies that the IS field is both a producer of ideas (exported to other fields) and a consumer of ideas (imported from other fields).

Motivations

The knowledge-network perspective indicates the need to understand the forces that shape the *market* for IS research. Two *demand-side* forces are apparent.

First, a steady increase in the infusion of IT in all areas of business has occurred. Even though the mere infusion of IT does not necessarily define the relevance of IS theories, the broad transformations that accompany IT infusion (in terms of product and process as well as various institutional aspects) enhance the ability of existing IS theories to address the attendant managerial issues. For example, recent articles on the use of electronic brainstorming and online focus groups in market research (e.g., Burke et al. 2001; Montoya-Weiss et al. 1998), the impact of technology infusion in customer service encounters (e.g., Bitner et al. 2000; Meuter et al. 2000), and consumer behavior in digital environments (e.g., Dholakia and Bagozzi 2001) have all identified research issues that underline the emerging relevance of IS theories and models in the marketing field.

Second, research issues in the management field are becoming increasingly interdisciplinary (i.e., linkages between the fields are becoming more important than the individual fields themselves). Researchers in different areas have generally become more receptive to collaborative research and to borrowing theories and models from other fields. In a recent Academy of Management Presidential address, Michael Hitt predicted that multidisciplinary thinking and collaborative work would soon radically redefine management research (Hitt 1998). Further evidence of this trend is provided by the creation of new journals (e.g., *Strategic Organization*, *Journal of Research in Marketing & Entrepreneurship*), new journal departments (e.g., the new Design and Operations Management department in *Management Science*), and journal special issues (e.g., the Fall 2000 special issue of INFORMS *Manufacturing & Service Operations Management* on the intersection between marketing and operations management).

A *supply-side* issue is also relevant. Specifically, the IS field has developed several products (i.e., theories and models) that are unique and valuable. Nonetheless, its future growth as a field would be enhanced by other fields using its products. Such cross-pollination between IS and other fields would allow us to identify specific opportunities to create new theories and refine old ones. At the same time, IS could also redefine its relevance to management research and practice.

Qualifications

An extensive debate on the nature and legitimacy of the IS discipline, its dependence on other disciplines, and the value of its theoretical and methodological diversity has taken place (Banville and Landry 1989; Benbasat and Weber 1996; Galliers 1995; Landry and Banville 1992; Robey 1996). Noting that the IS field lacks a clearly articulated core focus and set of theories, critics doubt IS can be a reference discipline for other fields. Baskerville and Myers address this concern in detail. The meaning of the term *reference discipline* as applied in this article is briefly discussed here.

Information Systems is an interdisciplinary, applied discipline. As such, it has drawn from many other disciplines to address issues that reflect the centrality of IT in varied socio-economic contexts. The IS field has not only borrowed theories and models from other disciplines, but adapted them to better suit IT-embedded phenomena, thereby building a sizeable portfolio of adapted theories, models, and concepts. Examples of such IS-adapted theories include the technology acceptance model (TAM) (Davis 1989), the IS implementation interaction theory (Markus 1983), the adaptive structuration theory (DeSanctis and Poole 1994), the task-technology fit theory (Goodhue and Thompson 1995; Zigurs and Buckland 1998), and the cognitive-affective model of organizational communication (Te'eni 2001). The IS field has a role as a reference discipline because its adapted theories are closer to the IT phenomena than the original theories and thus provide more powerful, parsimonious explanations.

For example, the resource-based view (RBV) in the strategy field is built on ideas first enunciated in industrial economics (e.g., Chamberlin 1933; Penrose 1959) and evolutionary economics (e.g., Nelson and Winter 1982). These ideas and models collectively referred to as RBV theory (Barney 1991; Wernerfelt 1984) have now found application in other management areas like marketing (Fahy and Smithee 1999) and product development (Verona 1999). As strategy is a reference discipline for marketing and NPD, so IS could be a reference discipline for NPD and other fields if it offers context-specific adapted theories, models, and concepts.

Implications

Baskerville and Myers outlined several implications of viewing IS as a reference discipline. These include the implications for the research agenda of individual researchers as well as the IS community, journals and editors (e.g., editorial decisions and plans), and institutions (e.g., incentive structures). These implications suggest a variety of questions. For example, to establish its position as a reference discipline, should the IS field seek out opportunities to make unique contributions to the other fields? How should individual researchers redefine the focus and scope of their work to serve a broader audience? What are the different ways in which we could enhance the accessibility of extant IS research findings? What are the lessons on serving as a reference discipline that IS can learn from other fields? How should we shape our contributions to the other fields to redefine our relevance and growth as a management field? These are all important questions with few clear answers. Yet, a goal of this paper is to expand the conversation on these issues by considering how IS could become an equal and effective partner in the NPD field's knowledge network.

There are two reasons for choosing NPD as the context to demonstrate the promise of IS as a reference discipline. First, NPD is an interdisciplinary, applied field with a clearly defined research focus and agenda. It has its own professional organization (Product Development and Management Association), journals (*Journal of Product Innovation Management*, *Visions*), and conferences. Like IS, NPD is a relatively young field of study and has drawn extensively from other management areas. If IS is to serve as a reference discipline, it will be easier for it to contribute to fields of similar maturity than to more established fields such as marketing and finance. The recent rapid infusion of IT in product develop-

ment activities also makes potential contributions from IS timely. Second, by establishing itself as a reference discipline for NPD, IS will signal its ability to contribute to disciplines closely tied with NPD. For example, IS can indicate its ability to contribute to an understanding of marketing issues such as Web-based marketing research methods (Dahan and Hauser 2002) by first applying IS adapted theories to issues related to customer co-innovation in virtual environments (Nambisan 2002).

In summary, three arguments that form the basis for much of this article are extended. First, strong market-related forces motivate the IS field to assume its role as a reference discipline. Second, IS will establish itself as a reference discipline by adapting theories from more basic disciplines (such as psychology, communications, and economics) and evaluating their potential to inform IT-related phenomena in other disciplines. Third, IS can contribute to other young, interdisciplinary areas while establishing its credentials to contribute to more mature, related management areas.

New Product Development and Information Systems

In many industries, the survival of firms is increasingly determined by their success in new product development (Cooper 2001; Schilling and Hill 1998). On average, more than one-third of a corporation's revenue comes from products that did not exist five years ago. That figure is much higher in certain technology industries (Griffin 1997). The importance of NPD is also reflected by the fact that its research and practice has come to the forefront of management dialog and attracted a large and diverse set of management, engineering, and manufacturing specialists. Although bound to the research and development (R&D) domain by tradition, NPD research has recently assumed a more interdisciplinary scope and focus. The field of NPD has been defined as including the set of activities "beginning with the perception of a market opportunity and ending in the production, sales, and delivery of a product" (Ulrich and Eppinger 2000, p. 2). Therefore, the dominant models in NPD emphasize an interdisciplinary mode of inquiry and call for contributions from most business functional areas.

NPD Field Evolution and the Emerging Role of IT

To appreciate the IS field's potential contribution to NPD research, one has to understand the evolution of the NPD field. Figure 1 depicts the knowledge network relevant to the NPD field, and Table 1 captures the characteristics of the NPD field's evolution.[2] While multiple disciplines have contributed to NPD research, its changing nature has brought different disciplines into focus at different times. The roots of the NPD field can be traced to the R&D and engineering management literatures of the 1960s and early 1970s. These two fields gave early NPD research a project- and innovation-management orientation. Initially, the primary focus was on managing and executing the R&D activity. However, as the need for the customer/market focus in NPD activities increased over the next decade, the marketing discipline also became a key contributor to NPD research. Themes such as the *voice of the customer* and *lead user* brought fresh insights to NPD. An increased emphasis was also placed on the organizational processes and communication that underlie product development. Consequently, organization theories became relevant. The organizational perspective elicited many issues related to NPD processes and activities including team structure and building, leadership, recognition and reward systems, team culture, conflict management, group decision making, and communication.

By the early 1990s, two other themes—operational integration and product development strategy—had assumed significance in NPD research. Increased globalization and competition

[2]Table 1 is derived largely from the author's personal research experience, over the last eight years or so, in NPD.

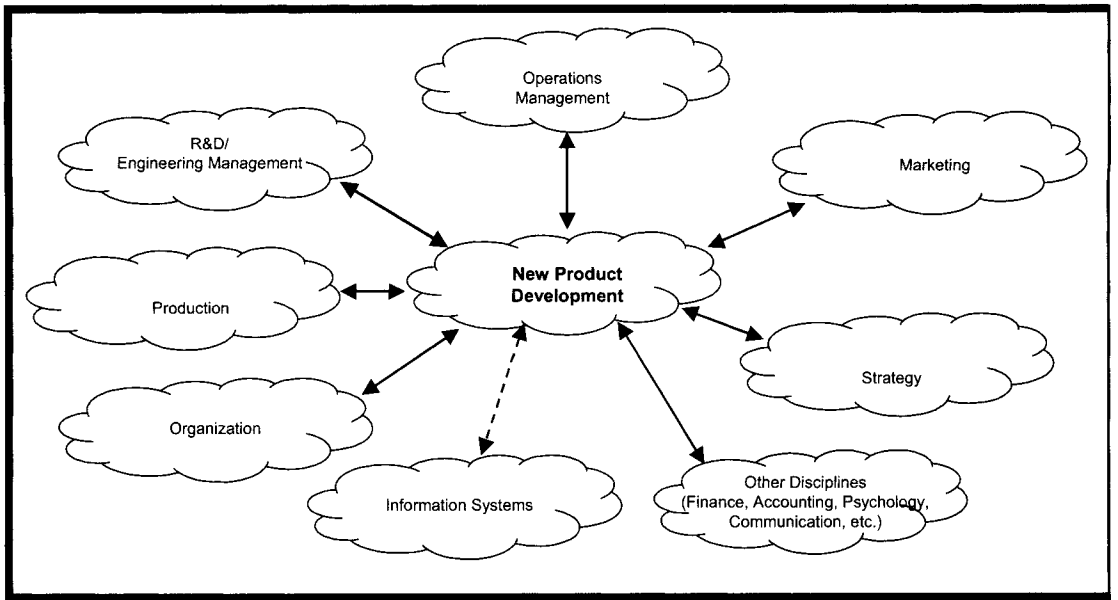

Figure 1. The Knowledge Network for the New Product Development Field

resulted in more dispersed product development activities and renewed emphasis on reducing development costs and time-to-market. Such enhanced operational efficiency in product development was made possible by more effective integration of NPD activities across the supply chain. Thus, issues such as supplier involvement in NPD, design for manufacturing, production process and schedule optimization, and process concurrency highlighted theoretical models and insights from the fields of operations management and production.

At the same time, highly dynamic product technologies and competition based on core competencies forced most organizations to ensure tighter linkages between their NPD projects and business strategy and to adopt coherent enterprise-wide NPD strategy. This led to the application of various concepts from the strategy literature (e.g., strategic product planning, technology planning, portfolio management, product platform strategy, technology alliances) in devising product development strategies.

From the mid-1990s on, the infusion of information and communication technologies in product development has raised the importance of IT in NPD. IT-enabled product development now has the potential to radically redefine the processes and outcomes of NPD:

> The aggressive implementation of information technology in the product development arena will reshape innovation as we know it. Unlike existing innovation processes, which are passive, the IT-enabled innovation processes...are active, directly supporting innovation activities. They will help in the analysis of data, enable more efficient communication and efficient problem solving, and achieve much higher levels of integration than possible earlier. They will make the organization more flexible and responsive, optimizing the process to fit the context of the project. (McGrath and Iansiti 1998, p. 2)

Table 1. NPD Field Evolution and the Role of IT

Characteristics of NPD Evolution	R&D/Engineering Management	Marketing	Organization	Strategy	OR/MS and Production	IT
Time of Emergence	1960s & early 1970s	1970s & early 1980s	1970s & early 1980s	late 1980s & early 1990s	late 1980s & early 1990s	mid-1990s
Dominant Perspective on NPD	NPD as an R&D or innovation project	NPD as a market-driven activity	NPD as an organizational process	NPD as an element of product/firm strategy	NPD as a sequence of development/ production steps	NPD as an IT-enabled innovation process
Key Focal Themes and Issues	Project management, technological innovation, engineering design management	Customer need identification, product positioning & scoping, integration with marketing plan	Team characteristics, internal/ external communication, leadership, culture, incentives, conflict management, team building	Portfolio management, strategic product & technology planning, platform strategy, alliances and networks	Development/ production process schedule, supplier selection, process performance modeling/ optimization	Knowledge management, support for collaborative/ distributed innovation, integrated process & project management
Performance Factors (dependent variables)	Technical performance, innovativeness, project cost	Fit with the market	Process success (perceptual measures)	Strategic alignment of product	Operational efficiency	??
Critical Contributions to NPD	Innovation management	Voice-of-the-customer, lead user	NPD team management, organizational alignment of NPD processes	Integrate R&D/ NPD portfolio with business strategy	Supply chain integration for NPD; design-for-manufacturing	??

Indeed, many of the challenges involved in the shift toward a product development chain or network—wherein the NPD project is divided among many players who accomplish their tasks simultaneously—cannot be addressed without the collaboration facilitated by IT (Dahan and Hauser 2001; McGrath and Iansiti 1998; Ozer 2000; Sawhney and Prandelli 2000). Moreover, the managerial issues associated with selection, deployment, and use of IT have become central to the success of product development efforts in most industries.

Recent publications in major NPD journals and conferences indicate the critical importance that both NPD practitioners and researchers now place on IT. For example, *Visions*, the flagship practitioner journal of the Product Development and Management Association, recently dedicated an issue (July 2001) to examining Web-enabled NPD technologies and tools. The number of vendors offering IT-based solutions for managing NPD has increased considerably in the last few years (Elliott et al. 2001). Seminars and workshops exploring IT-enabled product development issues abound, while several large firms including Intel, Cisco, and Sun have issued white papers on how they have started redesigning their product development using IT.

IT Infusion in NPD

The infusion of IT in NPD can be examined along four dimensions: process management, project management, information and knowledge management, and collaboration and communication.[3]

(1) *Process management:* Firms have started adopting structured NPD process management models to bring rigor and stability to their NPD activities. These models provide an overall process structure and metrics to manage the different phases of product development. Apart from generic and industry-specific process models and standards (e.g., CMM, Stage-Gate), several proprietary process models also exist (e.g., PACE). IT tools that support process management may either prescribe a comprehensive process model or enable firms to adopt a flexible process framework to configure their own unique process model (Elliott et al. 2001; Nahass 2001). IT support could also extend to cross-enterprise process specification and management as well as integration with other organizational and supply chain processes (Joglekar and Yassine 2002).

(2) *Project management:* This dimension relates to NPD project practices employed for task coordination, scheduling, and resource management. Sophisticated project management models enable firms to manage aggregate project portfolios and to implement cross-project resource management strategies based on real-time project data. They also provide complex workflow management capabilities to coordinate the activities of dispersed task groups in real time. Furthermore, the Internet, intelligent agents, and other emerging technologies facilitate enhanced online visibility of project data, automated task and resource monitoring, and control. New IT-based project management systems are designed to not only provide a virtual command center with access to all project information through a common interface but to also integrate project management with the firm's process management (McGrath and Iansiti 1998).

(3) *Information/knowledge management:* Modern NPD projects generate an extensive amount of information and knowledge. Techniques to support information sharing with multiple entities in a distributed innovation environment are now critical for NPD success. Moving away from traditional product data management (PDM) and product information management (PIM) systems and standards (e.g., the ISO-STEP), the newer IT-

[3]Note that specific IT applications and issues might overlap the above four dimensions. However, this framework allows us to identify and analyze the underlying research issues.

based systems are designed to support a wider variety of knowledge capture and sharing methods. They incorporate emerging data standards, databases, and visualization technologies that can handle different types of information (including graphics, audio, and video). They also attempt to offer more versatile decision support facilities capable of combining structured and unstructured information in real-time. These systems also facilitate sophisticated cross-project knowledge management critical for implementing enterprise-wide product platform and portfolio management strategies.

(4) *Collaboration and communication:* With the increase in the number and type of participants involved in NPD projects (e.g., customers, suppliers, complementors), support for collaboration has become more significant. Most NPD projects are cross-functional, and codeveloping products across organizational, cultural, and geographic boundaries has also become increasingly common (Dahan and Hauser 2001). The new IT-based systems that support such distributed innovation environments integrate a wide range of collaboration tools. Furthermore, such virtual collaboration systems have to cater to multiple NPD partners who differ in their IT capabilities, their need to access the project/product knowledge base, the nature of their participation in NPD, and their regional/organizational culture. Thus, the IT-based collaboration and communication systems used must be flexible and well-integrated with knowledge-management systems.

It is clear that a powerful set of IT tools to enhance the efficiency and effectiveness of NPD already exist. However, effective deployment of IT resources still requires careful consideration of their complex interplay with the product development context. Stakeholders must understand how IT shapes and is shaped by NPD processes and their outcomes, social and relational ties within and outside the NPD team, and cultural systems and political agendas. For example, how will the use of IT collaboration tools impact the NPD team's group identity? How will the values and norms of an NPD team redefine the manner in which the IT system is interpreted and used? As Orlikowski and Iacono (2001) note, the IS field can make unique contributions by addressing such issues that reflect the embeddedness of the IT artifacts in socio-economic contexts and practices.

Critical NPD Research Issues and Potential IS Contributions

The infusion of IT along the four NPD dimensions raises several research issues that could affect the success of product development. Table 2 identifies some of these issues and the IS research topics that could offer theories to address them. The objective is to demonstrate how the IS field might make unique theoretical contributions rather than to provide an exhaustive list of NPD research issues.[4] As Table 2 shows, many IS areas are relevant in the NPD context. The focus here is on two specific NPD research topics: namely, customer co-innovation in virtual environments and virtual product development teams.

New information technologies may radically transform the nature of customer involvement in NPD. Customers can contribute to value-creation activities including product conceptualization or ideation, product design and development, product testing, product marketing and diffusion, and product support through virtual customer environments (VCEs). Recent research (e.g., Dahan and Hauser 2002; Nambisan 2002; Prahalad and Ramaswamy 2001; Sawhney and Prandelli 2000; Thomke and von Hippel 2002) has identified several places where IS theories might be applied.

- First, customer co-innovation often occurs in a computer-mediated and community-oriented environment. The extant literature in

[4]Table 2 provides references to some of the articles that examine in greater detail the specific research issues related to each of the four IT application dimensions.

Table 2. Mapping the Potential IS Contributions to the NPD Field

Broad NPD Research Issues*	Sample NPD Studies that Identify the Research Issues in More Detail	Related IS Research Areas/Topics/Concepts*
1. **Process Management**		
• Design and implement NPD process models	Erlandson 2001; Howe et al. 2000; Nahass 2001	Software development process models Theories of collaborative IS development Workflow management models and systems Business process change and reengineering Interorganizational information systems Technology adoption/diffusion theories
• Coordinate NPD processes within and across enterprises	Joglekar and Yassine 2002; Olin et al. 1999	
• Facilitate concurrent product development and engineering	Eversheim et al., 1997; Hauptman and Hirji 1999; Prasad 2000	
• Integrate NPD processes with other business processes	Gerwin and Meister 2002; Joglekar and Yassine 2002	
• Integrate process management with project management	McGrath and Iansiti 1998	
• Adoption and impact of process tools and technologies	Maylor 2001; Nijssen and Frambach 2000	
2. **Project Management**		IS project management models IS project risk analysis S project team management theories Workflow management models and systems Interorganizational information systems IS project portfolio management theories DSS/GDSS theories IS project investment evaluation models
• Support strategic product planning and portfolio management	McGrath and Iansiti 1998	
• Cross-project resource and risk management	McGrath and Iansiti 1998	
• Integrated interorganizational project management	Hameri and Nihtila 1997	
• Project/technology investment evaluation	Lint and Pennings 2001; Neely and Neufville 2001	
• Real-time data support for project management	Howe et al. 2000; McGrath and Iansiti 1998	

*Note: This is only a representative and not an exhaustive list of research issues and areas. Please see the text for additional examples.

Table 2. Mapping the Potential IS Contributions to the NPD Field (continued)

Broad NPD Research Issues*	Sample NPD Studies that Identify the Research Issues in More Detail	Related IS Research Areas/Topics/Concepts*
3. **Information and Knowledge Management**		
• Support distributed knowledge creation and management	McGrath and Iansiti 1998; Ozer 2000; Sawhney and Prandelli 2000	Knowledge management support systems DSS/GDSS theories Visual interactive modeling (VIM) Database/data mining technologies Data/event representation models
• Support cross-enterprise product data interchange	Eversheim et al. 1997; Olin et al. 1999	
• Support cross-project organizational learning	Corso and Paolucci 2001	
• Enhance creativity in product design and development	Baba and Nobeoka 1998; Kappel and Rubenstein 1999	
4. **Collaboration and Communication**		Computer mediated communication Theories of collaborative IS development DSS/GDSS theories Technology adaptation theories Collaborative work/virtual team systems Models of open-source software development IS interface design theories Technology adoption/diffusion theories Individual/distributed cognition systems
• Support distributed innovation environments	Deck and Strom 2002; Hameri and Nihtila 1997; Sawhney and Prandelli 2001	
• Support customer co-innovation in virtual environments	Dahan and Hauser 2002; Nambisan 2002; Thomke and von Hippel 2002	
• Management of dispersed (virtual) new product development teams	Boutellier et al. 1998; Dahan and Hauser 2001	
• Support virtual product development management	Dahan and Hauser 2002; Dahan and Srinivasan 2000	

*Note: This is only a representative and not an exhaustive list of research issues and areas. Please see the text for additional examples.

areas like computer-mediated communication (CMC), computer-supported collaborative work (CSCW), and group support systems (GSS) (e.g., Benbasat and Lim 1993; Dennis et al. 2001; DeSanctis and Poole 1994; Postmes et al. 2000; Sproull and Kiesler 1991; Te'eni 2001; Walther 1996; Zigurs and Buckland 1998) will potentially be relevant. This literature could suggest how the characteristics of the computer-mediated environment shape the pattern of customer interactions in a VCE (and thereby their innovative inputs). The temporal structure afforded by the medium is a good example. Studies show that anticipation of future interactions is a potent predictor of several relational communication dimensions (Walther 1994). The expectation of long-term interactions may therefore lead VCE users (i.e., customers) to invest more in understanding other users' social cues, thereby enhancing their overall community orientation.

- Second, IS research in knowledge support systems, decision support systems (DSS), data visualization, and visual interactive modeling (e.g., Alavi 2000; Alavi and Leidner 2001; Belton and Elder 1994) offers valuable insights into customers' varied knowledge creation activities in VCEs. Studies on IT and distributed cognition in organizations (e.g., Boland et al. 1994) that draw on hermeneutics, inquiry systems, and related areas, for example, could offer a theoretical framework for understanding customers' individual product interpretations and group dialogues in VCEs. Similarly, DSS research on mental models (e.g., Vandenbosch and Higgins 1996) could provide theoretical insights into how customers build and maintain mental models as they process different types of information in the VCE. Such insights will be particularly valuable in VCE contexts where vendors ask participants to judge new product concepts and prototypes. Research on DSS and visualization (e.g., Belton and Elder 1994; Angehrn and Luthi 1990) could offer models for how the visualization of product-related issues in VCEs might enable customers to both construct and critique cognitive maps of those issues. Finally, DSS studies (MacCrimmon and Wagner 1994) could clarify idea stimulation and creativity enhancement in VCEs.

- Third, recent work in IS that draws on human-computer interaction theories to understand Web interface design has important implications for VCE. The para-social presence construct (Kumar and Benbasat 2001, 2002), based on the social presence concept, treats the medium (e.g., a Web site) as a social actor and captures the underlying psychological cues that reflect the intensity of interactions between the customer and the web site. These insights can be extended to the VCE context to analyze customer's interactions as an autonomous agent of innovation in product testing where the interactions occur between the customer and the virtual product testing center. Similarly, virtual reality tools now provide customers with simulated product experience in both product development (Dahan and Hauser 2002) and online shopping (Li et al. 2000) contexts. Ongoing IS research theorizing customers' experiences with virtual products could offer insights on the interpretation of customer information gleaned from virtual product forums. Finally, recent IS studies (e.g., Koufaris 2002) on other psychological aspects of Web interface, such as the elicitation of human emotions and their impact on consumer behavior, could also prove informative for NPD.

An increasing number of firms (e.g., Boeing, IBM, GE, Microsoft) rely on *virtual product development teams* to minimize their product development costs and time-to-market (Boutellier et al. 1998; Dahan and Hauser 2001; Hameri and Nihtila 1997; Ozer 2000). Many theoretical insights needed to manage product development teams in virtual environments can be derived from the extant IS research on related topics.

- First, IS studies based on theories like structuration theory (e.g., DeSanctis and Poole 1994; Orlikowski 1992, 1996) can inform the adaptations a virtual product development team might make to the collaborative information technologies that constitute their virtual team environment. For example, insights might be obtained on the nature of the adaptations; the roles of pre-existing organization, group, and technology structures on such adaptations; and the impact of the adaptations on NPD outcomes (e.g., Majchrzak et al. 2000; Maznevski and Chudoba 1998).

- Second, IS studies in the area of virtual teams and computer-mediated groups (e.g., Beranek 2000; Chidambaram 1996; Duarte and Snyder 1999; Iacono and Weisband 1997; Jarvenpaa and Leidner 1999; Saunders 2000; Walther 1996) may inform issues of trust, identity, and relational ties in virtual product development teams. Drawing on the *swift trust* concept, Jarvenpaa and Leidner (1999) examined the development of trust and its attendant communication behaviors within global virtual teams. This and similar studies could provide the theoretical foundation for future NPD work that analyzes the mechanisms for the development of trust, group identity, and cohesiveness in virtual product development teams.

- Third, recent IS studies on knowledge sharing and management in virtual teams (e.g., Cramton 2001; Malhotra et al. 2001) could inform a host of NPD issues. These might include the accommodations to be made in team practices to suit knowledge sharing needs and collaborative technologies, the development of shared interpretive understanding among team members, the structuring of knowledge management systems for different types of innovation (e.g., radical, incremental), and the impact of different knowledge sharing practices on NPD outcomes.

- Fourth, the extant literature on GDSS may inform future research on decision making in virtual product development teams. Although GDSS studies have produced conflicting results, recent efforts have focused on integrating multiple theoretical perspectives to better understand the determinants of GDSS outcomes. For example, Dennis et al. (2001) conducted a meta-analysis of GDSS studies incorporating both the *task-technology fit* and the *appropriation support* perspectives. The insights from this type of work could be applied to the study of decision making in virtual product development teams.

IS theories may also be relevant to other NPD issues. For example, models on the escalation of commitment in IS projects (e.g., Keil 1995; Keil et al. 2000) could apply to the study of NPD project resource use and management. Similarly, *real option* models developed to evaluate IS projects (e.g., Benaroch and Kauffman 1999; Kim and Sanders 2002) could prove useful in evaluating investments in technology-intensive NPD projects (McGrath and MacMillan 2000). Finally, technology adoption theories such as TAM (Davis 1989) could inform the adoption of technology-based systems in NPD.

IS theoretical contributions to NPD could assume different forms. In some cases, prior IS findings could directly help researchers understand NPD-related issues. In other cases, extant IS theories might simply be appropriate starting points for future NPD investigations. Therefore, the most appropriate indicator of whether IS is indeed a reference discipline for NPD will be a cumulative pattern of citations to particular IS theories and models. Further, in each of these cases, IS-adapted theories are closer to the IT-infused NPD context than the original theories. For example, consider TAM in comparison to either the theory of reasoned action or the theory of planned behavior. IS-adapted theories accordingly promise more powerful, parsimonious explanations of IT-related phenomena in NPD than the original theories.

Lessons from Other NPD Reference Disciplines

Several management disciplines including marketing, operations management, and strategy have contributed to NPD research. The nature of these contributions and the manner in which they have been made can usefully inform the IS field.

The linkage between the NPD and IS fields must be examined to identify those areas where contributions might be made. This article provides a starting point, but a systematic analysis of the literature in the two fields is still needed. Agenda-setting articles have clarified research issues and identified important theoretical perspectives in each NPD reference discipline. In addition to providing a focus for future research, review articles like the following also integrate work in common areas: marketing and NPD (Griffin and Hauser 1996; Mahajan and Wind 1992); strategy and NPD (Cusumano and Nobeoka 1992); operations management and NPD (Krishnan and Ulrich 2001); organization theory and NPD (Brown and Eisenhardt 1995). Review articles that bridge the contributions to NPD of two or more disciplines have also appeared. Tatikonda and Montoya-Weiss (2001), for instance, combine marketing and operations research perspectives for managing NPD.

Because the linkages between the fields are bi-directional, reference disciplines could also import knowledge from the NPD field. For example, modularity is a concept innate to the product development area (Baldwin and Clark 2000; Schilling 2000). Many technology firms have adopted modular product architectures as the basis for new product design to enhance product flexibility, yet these have implications beyond NPD. Specifically, product modularity may also transform a firm's marketing processes. Sanchez (1999) studied the implications of product modularity on market research and development, marketing strategy, distribution channel design, and the boundaries of the marketing organization. Product modularity may also imply changes in organizational structure and knowledge systems and so pose complex research questions for organizational theorists (Sanchez and Mahoney 1996). NPD could even serve as a vehicle to advance IS research because it provides a context wherein disparate IS research streams could converge to generate new theories. The development of IT tools for process coordination in cross-enterprise NPD projects, for example, calls for combining concepts and models from diverse IS areas such as workflow management, software engineering, and interorganizational information systems.

Finally, many forums for communicating research contributions to NPD exist. While the *Journal of Product Innovation Management*, *Research Policy*, *R&D Management*, and *Research-Technology Management* form the primary outlets for NPD research, most other management journals (e.g., the Academy of Management journals, the INFORMS journals, the American Marketing Association journals, the IEEE journals, etc.) also publish a sizeable number of NPD related articles. Most disciplines have also created special interest groups (SIGs) to nurture research on their connection to NPD. For example, the technology management subdivision of the INFORMS hosts the interactions on the intersection between OR/MS and NPD. Similar SIGs in other areas and their related conference tracks (e.g., American Marketing Association, Strategic Management Society) also serve as valuable outlets. By affiliating IS-related inter-disciplinary SIGs with organizations such as the Association for Information Systems, the IS community can both encourage interdisciplinary research and enhance the appeal of its conferences within other fields. Similarly, journals that already have a well-established audience in both the IS and NPD research communities (e.g., *IEEE Transactions on Engineering Management*) could become forums to host special issues that focus on the intersection of these two disciplines.

Conclusion

This article extends the debate on the emerging vision of IS as a reference discipline. By employing NPD as the context, it shows the rich

potential for the IS field to assume such a role in the knowledge networks of the management field. It also indicates the need for IS researchers to broaden their research perspectives, enrich the management dialog, and thereby enhance the growth of the IS field itself. Hopefully, the issues raised here will provoke further debate within the IS community and lead to the creation of a research agenda that truly reflects the "coming of age" of the IS discipline.

Acknowledgements

I would like to thank Ron Weber and the three anonymous reviewers for their insightful comments and suggestions on an earlier version of this article.

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