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Understanding the influence of information systems competencies on process innovation: A resource-based view ☆

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Abstract

The resource based view of firms is used to explore how information system (IS) competencies affect process innovation in an organization. Data was collected through a case study of two process innovations at a healthcare firm in the United States. The findings illustrate how six IS competencies – Knowledge Management, Collaboration, Project Management, Ambidexterity, IT/Innovation Governance, Business-IS Linkages – can differentially affect the conception, development and implementation of process innovations. Implications for researchers and practitioners are drawn from these conclusions and suggestions for further research are proposed.

Keywords: Process innovation; Resource based theory; Information systems competencies; Case study; Healthcare

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1. Introduction

The resource based view (RBV) of the firm suggests that organizations compete and create value on the basis of resources that are unique, rare, valuable, and not easily imitable or substitutable (Barney, 1991; Conner, 1991). Competencies[3] develop when such resources are combined to create specific organizational abilities (Teece et al., 1997). Sambamurthy and Zmud (1994) and Feeny and Willcocks (1998), incorporating concepts of the RBV in IS research, suggest that organizations can better understand the benefits of using IS by considering how different IS-related competencies generate business value. Subsequent studies have examined the effects of IS resources and competencies on overall firm performance (Bharadwaj, 2000; Ravichandran and Lertwongsatien, 2005; Santhanam and Hartono, 2003), and on antecedents of firm performance, such as supply chain integration (Rai et al., 2006) and ability to sustain competitive advantage (Pavlou and El Sawy, 2006; Wade and Hulland, 2004). In this paper, we examine the role of IS competencies in supporting another antecedent of firm performance, process innovation.

Understanding the link between IS competencies and process innovation is important for two reasons. First, in recent business history, much of the innovation that has been adopted as business practice relies heavily on information systems (IS) and information technology (IT) for practicality (Bassellier and Benbasat, 2004). For instance, firms have used sophisticated IT-based control systems to implement process controls in the chip fabrication process, required for the development of complex and faster microprocessor chips (Thomke, 2006). Similarly, firms in the retailing industry have used applications to create innovations in inventory control, supply chain management and customer relationship management (Farrell, 2003). Second, for today's Internet based or "net enabled" organizations (Wheeler, 2002), process innovation is largely IT-enabled and requires a deep understanding of IS competencies and resources (Sambamurthy et al., 2003).

A number of studies enumerate ways in which IT can support process innovation and process re-engineering, such as through the use of process design and simulation software (Davenport, 1992; Serrano and den Hangst, 2005), the provision of a flexible infrastructure (Broadbent et al., 1999) or the facilitation of activities such as project management (Attaran, 2003). The focus has been on the role of different technologies and individual activities and does not address the combined and integrated influence of technology, IS professionals, and governance and managerial mechanisms needed for successful process innovation. For instance, the presence of a good process modeling tool would not be useful in facilitating process innovation, in the absence of managerial mechanisms that foster collaboration between process experts (who understand the process and the business workflows) and IS professionals (who understand tool usage).

The research reported in this paper has two objectives. The first is to demonstrate the value of the competency perspective of the RBV for analyzing how IS (technologies and associated managerial resources and mechanisms) can influence the success of process innovation. We use the competency perspective to integrate prior IS research about individual factors that affect the success of process innovation, and to provide a systematic framework for understanding the role of IS therein. The second is to

[3] Competencies have also been referred to as "Capabilities" (Day, 1994; Grant, 1991; Nanda, 1996).

understand how specific IS competencies influence an organization's ability to conceive, develop and implement process innovations. This research is based on longitudinal and exploratory case data from two process innovations at a healthcare organization in the United States.

In the next section, we present the theoretical background for the study and describe the main conceptual streams on which it is based. In Section 3 we present the research model. This is followed in Section 4 by a description of the case study site, including the process innovations studied and relevant methodological details. In Section 5, we present and analyze the data. Discussions and concluding remarks are presented in Sections 6 and 7, respectively.

2. Conceptual foundations

This research rests upon foundations in two broad areas of study – the resource-based view of IS and the application of IS to process innovation. In this section, we review prior work done in each area and conclude with a review of work done at the intersection, namely the resource-based view of how IS supports process innovation.

2.1. Resource-based view of information systems

The resource-based view of the firm has its genesis in the fields of strategy and organization structure. The term was coined by Wernerfelt (1984), but its derivation is generally attributed to Penrose (1959). The RBV posits that a firm is characterized by its unique resources whose control, use, and disposition by management help to determine its value. Resources are "stocks of available factors that are owned or controlled by the firm" (Amit and Schoemaker, 1993). They can be tangible assets, such as plant technology, capital equipment, facilities and raw materials (Itami, 1987). They can also be intangible assets, such as skills, judgment, insight and experiences of individual employees; brand names and patents (Barney, 1991; Grant, 1991).

Competencies (Teece et al., 1997) are developed when combinations of resources are applied together to create specific organizational abilities. A competency is, therefore, a firm's ability to deploy resources in combination or bundles, so as to create a capacity for achieving a desired objective. Competencies are a firm's distinctive abilities, developed as a result of the deployment of combinations of individual resources in unique ways, and through specific organizational routines (Amit and Schoemaker, 1993; Grant, 1991). The idea of competencies includes the notions of "core competence" (Prahalad and Hamel, 1990) and "distinctive competence" (Snow and Hrebiniak, 1980). Competencies help firms achieve superior performance (Eisenhardt and Martin, 2000; Teece et al., 1997) because they are specific and distinctive to a firm (Conner, 1991). They are difficult to imitate because they are embedded within the firm's culture and routines (Day, 1994) and because their path dependencies to organizational performance are not always transparent (Barney, 1991; Dierickx and Cool, 1989; Grant, 1991).

How has the resource-based view been applied to IS literature? The RBV literature classifies an organization's IS-related resources into three broad categories: technical, human, and intangible. Technical resources include physical IT assets such as hardware, software, databases, applications and networks (Armstrong and Sambamurthy, 1999; Bharadwaj, 2000; Keen, 1993; Lopes and Galletta, 1997; Weill and Broadbent, 1998), as well as firm-specific proprietary technology and applications (Mata et al., 1995). They form a platform on which information systems are built and provide the tools for processing, transferring, storing and retrieving information. IS-related human resources comprise the skills of IS professionals, including technical skills (Bharadwaj, 2000; Mata et al., 1995; Peppard and Ward, 2004; Ross et al., 1996; Weill and Vitale, 2002), experimentation and innovation skills (Jarvenpaa and Leidner, 1998; Wade and Hulland, 2004) and skills in IT management, communication, and understanding of the business (Copeland and McKenney, 1988; Feeny and Willcocks, 1998; Mata et al., 1995; Wade and Hulland, 2004). Intangible IS resources include knowledge assets, a customer orientation, a flexible IS culture (Bharadwaj, 2000), vendor relationships (Powell and Dent-Micallef, 1997), end user and top management relationships (Ross et al., 1996), and partnerships between IT and business units (Bassellier and Benbasat, 2004).

An IS competency is created when processes and structures are applied in non-transparent and inimitable ways to combinations of IS resources, to develop specific abilities for accomplishing IS-related organizational tasks. IS competencies are, therefore, embedded in organizational processes and business routines (Teece, 2000). Recent IS research has converged on the conclusion that IS competencies positively influence organizational performance. Studies have attempted to classify various IS competencies (Feeny and Willcocks, 1998; Wade and Hulland, 2004) and have analyzed their effects on parameters such as "success in electronic commerce" (Montealegre, 2002), "organizational performance" (Peppard and Ward, 2004), "customer service excellence" (Ray et al., 2004), "competitive advantage" (Bhatt and Grover, 2005) and "support for core competencies" Ravichandran and Lertwongsatien (2005). Table 1 summarizes this research.

2.2. The role of IS in process innovation

"Business innovation" is defined as ***an idea, practice, behavior or artifact that is perceived as being new by the adopting unit*** (Daft, 1978; Damanpour, 1991; Tushman and Nadler, 1986; Zaltman et al., 1973). The literature distinguishes between technical innovations, those that involve new technologies, products and services; and administrative innovations, those that involve procedures, policies and organizational forms (Daft and Becker, 1978; Damanpour, 1987; Kimberly and Evanisko, 1981). In this paper, we focus on administrative innovations, specifically those that involve procedures or processes. Process innovation is a change in the way a product is made or a service is provided (Robey, 1986; Zmud, 1982). It is the introduction of new methods, procedures or responsibilities within the organization (Davenport, 1992). It includes the acquisition of new skills and requires new ways of managing and organizing (Robey, 1986).

What is the role of IS in facilitating process innovation? Because process innovation is an aspect of business innovation, it is necessary in this context to examine the role of IS not only in process innovation, but also more generally in business innovation. Various roles and requirements for IS in business innovation have been identified in the IS literature. For example, Ramiller and Swanson (2003) find that an organizing vision for IT stimulates invention and experimentation and legitimizes innovation as good organizational practice. Malhotra et al. (2005) show that inter-organizational

Table 1
Constructs for IS competencies

Source	Competency constructs	Dependent variable
Feeny and Willcocks (1998)	IS/IT governance Business system thinking Business-IS relationship building Designing technical architecture Making technology work Informed buying of IT services Contract facilitation Contract monitoring Vendor development	None
Montealegre (2002)	Capability to strategize Capability to be flexible Capability to integrate Capability to engender trust	Success in electronic commerce
Peppard and Ward (2004)	Strategy formulation • Business strategy • Technology innovation • Investment criterion • Information governance IS strategy • Prioritization • IS strategy alignment • Business process design • Business performance improvement • Systems and process innovation IT strategy • Infrastructure development • Technology analysis • Sourcing strategies Exploitation • Benefits planning • Benefits delivery • Managing change Deliver solutions • Applications development • Service management • Information asset management • Implementation management • Business continuity and security Supply • Supplier relationships • Technology standards • Technology acquisition • Asset and cost management • IS/IT staff development	Organizational performance

(*continued on next page*)

Table 1 (*continued*)

Source	Competency constructs	Dependent variable
Ray et al. (2004)	Managerial IT knowledge	Competitive advantage through customer service excellence
Wade and Hulland (2004)	External relationships management Market responsiveness IS business partnerships IS planning and change management IS infrastructure[a] IS technical skills[a] IS development capability Operational efficiency	
Bhatt and Grover (2005)	IT infrastructure[a] IT business experience Relationship infrastructure	Competitive advantage
Ravichandran and Lertwongsatien (2005)	IS planning sophistication Systems development capability IS support maturity IS operations capability	Firm performance through support for core competencies
Ray et al. (2005)	Shared knowledge IT infrastructure flexibility	Customer service process performance

[a] Items should be classified as IT resources rather than IS competencies, but they are included here because they are mentioned in parallel with the other competencies by the research cited.

linkages in the supply chain combined with a knowledge management capability creates a capacity for continual innovation. Although the dependent variable in these studies is business innovation, process innovation is implicitly included. Also, even though the studies make no reference to the RBV, it is clear that the IT related roles and requirements they identify could be considered competencies, as they derive from technical, human, and intangible resources of the firm and they satisfy the requirement of combining these resources in non-transparent and inimitable ways. Table 2 summarizes the research on the IS roles, activities, and requirements related to business innovation.

The role of information systems and technology in supporting process innovation can be found in various literature streams, including business process redesign (Davenport, 1992; Khosrowpour, 2006; Reijers and Mansar, 2005; Tsai, 2003), organizational assimilation of IT (Fichman and Kemerer, 1997), innovation diffusion (Bofondi and Lotti, 2006; Fichman and Kemerer, 1999; Florkowski and Olivas-Luján, 2006), IT strategy (Fincham et al., 1995; Pennings and Harianto, 1992; Ross et al., 1996; Souitaris, 2002), and electronic linkages and alliances (Malhotra et al., 2001; Pennings and Harianto, 1992; Tikkanen and Renko, 2006; Xie and Johnston, 2004). IT often enables process automation (Nissen and Sengupta, 2006; Scheer et al., 2004) and improves process control through the use of workflow systems (Muehlen, 2004). Process design software (Nurcan et al., 2005; Vollmer and Peyret, 2006) and simulation systems (Baldwin et al., 2005; Serrano and den Hangst, 2005) have become standard tools for process innovation and redesign. Although the impact of process innovation on firm success is mixed, research shows that

Table 2
Summary of IS roles, activities, and needs from IS research on business innovation

Source	IS roles, activities, and needs
Howells (1997)	Hybridization of knowledge
Boutellier et al. (1998)	Communication and coordination
Prasad (2000)	Knowledge management Communication and coordination Workflow management
Sawhney and Prandelli (2000)	Governance
Corso and Paolucci (2001)	Knowledge management
Malhotra et al. (2001)	Collaboration Knowledge management
Khoo et al. (2002)	Customer linkages
Zahra and George (2002)	Opportunity recognition
Nambisan (2003)	Information/knowledge management Collaboration and Communication Project management Process management
Ramiller and Swanson (2003)	Organizing vision
Bassellier and Benbasat (2004)	Business competence of IT professionals
Gloet and Terziovski (2004)	Knowledge management
Hackbarth and Kettinger (2004)	Strategic vision Operational excellence IS leadership
Mark and Monnoyer (2004)	IT knowledge of business leaders Business competence of IT professionals Business involvement of IT professionals Strategic vision Operational efficiency
Kor and Mahoney (2005)	Governance
Krafft and Ravix (2005)	Governance
Malhotra et al. (2005)	Knowledge management Operational efficiency Supplier linkages
Fairbank et al. (2006)	Strategy
Ferneley and Bell (2006)	Bricolage (improvisation) Strategic vision Rationalization Alignment of IS and business
Savory (2006)	Knowledge translation

increasing the investment in IT increases the impact of process innovation on firm performance (Devaraj and Kohli, 2000).

The process innovation literature identifies a number of innovation-enabling IS activities and roles. For example, Attaran (2003) suggests that infrastructure flexibility, collaboration with suppliers and distributors, project management, process analysis, and data communication and database skills and resources are critical for the success of a process redesign effort. Al-Mashari and Zairi (2000) find IS integration, process modeling, and the alignment of IT and business goals to be important. Broadbent et al. (1999) see "IT infrastructure capability," as measured by the extent of infrastructure services, the provision of boundary-crossing services, and IT reach and range, as a key antecedent of process redesign success. Table 3 summarizes the research on the IS roles and activities related to process innovation.

2.3. The resource based view and process innovation

Despite the presence of research applying the resource-based view of the firm to IS (Table 1) as well as research relating IS and IT to business and process innovation (Tables 2 and 3), research is relatively sparse in the intersection between these two areas, namely, applying a resource-based or competency-based view of IS for process innovation. Consequently, while there is mention of numerous individual and fragmented activities, roles and requirements with respect to IS and IT that facilitate process innovation, there is a lack of a systematic approach for analyzing what organizations need from their IS, for effective process innovation.

Some recent studies have applied the resource-based lens to explain the relationships between IS and the performance of different processes. Ray et al. (2005) have found that the capabilities of shared knowledge and IT infrastructure flexibility positively influence the performance of the customer service process. Rai et al. (2006) show that IT infrastructure integration capability leads to better integration of supply chain processes and better firm performance. Sambamurthy et al. (2003) argue that IT capabilities influence firm performance through their influence on the strategic processes of "capability building", "entrepreneurial action", and "co-evolutionary adaptation". Bhatt (2000) makes a good case for applying the RBV to assess the IS competencies and capabilities a firm needs for successful process innovation, and focuses on one such competence-knowledge management. Bhatt (2000) and Sambamurthy et al. (2003) are theoretical treatises, and neither presents any empirical support. In this paper, we build on these ideas to propose and validate an approach for systematic analysis of the role of IS in process innovation. We do this by building linkages between the RBV and process innovation literatures and identifying a range of IS competencies that facilitate process innovation.

3. Research model

Our research question is "How do IS competencies facilitate process innovation?" In creating a research model, our objective was to draw from the literature a comprehensive, yet parsimonious set of competencies, which can be analyzed as to their effect upon process innovation. The constructs for IS competencies appearing in the RBV literature (see Table 1) have inconsistent terminology and are overlapping. Ray et al. (2004) observe that if such is the case, then it is necessary, when investigating the impact of competencies on the effectiveness of a business process or routine, to first identify those competencies relevant to the context under investigation. A number of studies in the strategic management literature (Henderson and Cockburn, 1994; Schroeder et al., 2002, e.g.) have followed this technique.

Table 3
Summary of IS roles and activities from IS research on process innovation

Source	IS roles and activities
Kogut and Zander (1992)	Combinative ability (knowledge management)
Broadbent et al. (1999)	Infrastructure management
Al-Mashari and Zairi (2000)	Integration/alignment with business Process modeling
Bhatt (2000)	Knowledge management Organizational flexibility
Attaran (2003)	Infrastructure flexibility Communication Collaboration Coordination Project management Process analysis
Den Hengst and de Vreede (2004)	Collaboration Process simulation/modeling
Mustonen-Ollila and Lyytinen (2004)	Knowledge transfer mechanisms Slack IS resources
Elliman et al. (2005)	Process modeling
Marjanovic, 2005	Knowledge management Coordination
Serrano and den Hangst (2005)	Process simulation/modeling
Adamides and Karacapilides (2006)	Knowledge management Process modeling
Gebauer and Schober (2006)	Flexibility
Karahanna and Watson (2006)	IS leadership
Shin (2006)	Inter-organizational systems
Jung et al. (2007)	Knowledge management

We have used a similar approach and have followed a two-step process to identify the IS competencies expected to influence process innovation. First, drawing from the literature on business innovation and process innovation summarized in Tables 2 and 3, we identified those IS competency terms, roles and activities that could affect process innovation. To give an example, terms that related to "knowledge management" (Bhatt, 2000; Savory, 2006 for instance) or "combinative ability" (Kogut and Zander, 1992) were expected to influence process innovation. Similarly, terms relating to "governance" (Kor and Mahoney, 2005; Sawhney and Prandelli, 2000 for instance) would influence process innovation. Second, having identified the IS competency terms that were expected to affect process innovation, we applied a technique similar to hierarchical clustering to categorize them. To begin with, the terms most similar to one another were grouped together. This process was repeated iteratively until no further grouping was possible. For example, at some point, the term "hybridization of knowledge" was grouped with the term "knowledge management." In this case, we used the name of

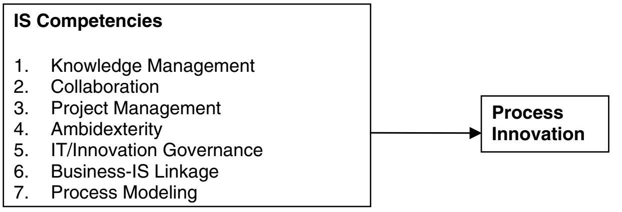

Fig. 1. Research model.

one of the groups, "knowledge management" to apply to the combined group. In most cases, this was possible. In some cases, such as when combining "alignment of IS and business" with "business competence of IS professionals," we constructed a new term, "Business-IS Linkage."

Fig. 1 illustrates our research model. The seven IS competencies derived from the literature are the independent variables affecting process innovation. Our research is intended to explore if these variables do, indeed, influence the success of process innovation, and to illustrate the mechanisms through which this influence operates. In the remainder of this section, we expand on the IS competencies and provide additional support for their inclusion in the model.

3.1. Knowledge management

We define an organization's knowledge management competency as its facility for developing and exploiting its knowledge assets with a view toward furthering its objectives (based on Davenport and Prusak, 1998; Metaxiotis et al., 2005. See Choy et al., 2006, Table 1 for other definitions of knowledge management drawn from the literature). Activities associated with knowledge management include creating, storing/retrieving, transferring, and applying knowledge (Alavi and Leidner, 2001). Darroch and McNaughton (2002) developed a 16-item instrument with three sub-factors – knowledge acquisition, knowledge dissemination, and responsiveness to knowledge – to measure an organization's knowledge management competency. A competency in knowledge management require IT resources such as expert systems and data mining software for knowledge creation and abstraction, database systems for storage and retrieval, portals for knowledge dissemination, and decision support systems for knowledge application.

The knowledge management competency is critical to successful innovation because the innovation process is, by its nature, knowledge intensive (Gloet and Terziovski, 2004). An innovator might start with an idea and a personal base of knowledge. But, to transform the idea into a new product, service, or process, innovators typically need to find and integrate external information, prior research, and the knowledge and expertise of others. Firms with a knowledge management competency can capture knowledge and related information and make them accessible to knowledge workers and innovators. By connecting isolated "pockets of innovation," knowledge management tools help these firms diffuse knowledge efficiently and effectively (Tuomi, 2002). This is important because companies generate more innovations and innovations of higher value when they draw from a conceptually and geographically diverse pool of knowledge (Santos et al., 2004). In addition, innovators develop their skills and understanding more rapidly in the context of a knowledge management environment (Carneiro, 2000).

3.2. Collaboration

We define collaboration as two or more entities working together toward a common goal. When collaborators are separated (rather than being collocated in time and space), information technology, such as communication networks, email, webcams, file-synchronization software, multi-user editors, wikis, encryption software, and portals can help an organization develop a competency in collaboration. Cross-company collaboration, in particular, demands such a competency.

It should be noted that competency in collaboration does not imply competency in knowledge management, as it does not insure the retention of knowledge gained during the collaborative effort nor does it ensure that parties working toward other goals or on other projects have access to information generated during the collaboration. Similarly, competency in knowledge management does not imply competency in collaboration. For example, if one researcher can access the research published by another, it does not imply that the two researchers are collaborating or that the firm has the ability, culture, or communication means (for example, if they are in different offices or countries) for them to collaborate effectively.

A competency in collaboration supports the initial stages of innovation as well as the work needed to develop and implement an innovative idea. At the front end of the innovation process, a competency in collaboration allows members of a team to stimulate each other's creative efforts by sharing knowledge and information that could provoke new ideas or solutions (Madjar, 2005). This is an example of the whole being greater than the sum of its parts; the team's creativity is likely to exceed the sum of the creativity of its individual members (Pirola-Merlo and Mann, 2004; Taggar, 2002). In the development and implementation stages of an innovation, a competency in collaboration allows teams with the requisite knowledge and expertise to be assembled, irrespective of where their members reside geographically and or are employees of the firm (McKnight and Bontis, 2002; Zakaria et al., 2004).

3.3. Project management

We define project management to include activities involved in initiating, planning, executing, controlling, and terminating a project. As an IS competency, project management draws on hardware and software for storing and manipulating product and process data, and software for scheduling and tracking tasks, assigning and monitoring staffing, and documenting and evaluating progress at milestones.

Research shows that a competency in project management is critical to a company's ability to innovate (Thieme et al., 2003). This is especially true during the later stages of innovation, as new ideas receive funding and develop into projects intended for bringing them to the market or for internal implementation. Project management provides control, helps keep team members focused and on schedule, and helps innovation leaders operate more efficiently (Kenny, 2003; Tomala and Senechal, 2004). In large firms, project management data from hundreds or thousands of projects can be rolled up to provide data on the company's innovation portfolio. This aggregate data can help management decide where to place resources and when to cut losses, (Benko and McFarlan, 2004; Cooper et al., 2004; Walsh, 2001).

3.4. Ambidexterity

Ambidexterity is the ability to achieve and balance strategic vision and operational excellence. Competency in ambidexterity includes competencies in these two aspects as well as the technical and organizational flexibility to vary the balance between them in response to external conditions and internal needs. Ambidexterity finds example in a number of concepts that deal with different types of "contradiction". According to O'Reilly and Tushman (2004), organizations, in order to sustain innovation, need to operate in two modes simultaneously. In the first, they need to provide stability to their existing products and processes by building in efficiency, consistency and reliability in their routines. In the second, they need to experiment, explore and improvise, to build the bases for the creation of new products, services and processes. The first requires highly formalized roles and responsibilities, centralized procedures, and efficiency oriented cultures. The second kind requires experimental and entrepreneurial cultures, and flexible routines and work processes (Ferneley and Bell, 2006; Nonaka, 1995). From the domain of strategic management, Gupta et al. (2006) suggest that organizations need to "explore" new knowledge in order to engage in learning and innovation. At the same time, they need to "exploit" existing resources and knowledge to achieve efficiency in their operations. Schreyögg and Kliesch-Eberl (2007), drawing from the concepts of core rigidities (Leonard-Barton et al., 1992) and dynamic capabilities (Eisenhardt and Martin, 2000; Teece et al., 1997) point to the paradox inherent in building capabilities through complex and reliable organizational routines and processes, and getting locked into the same routines at the cost of being able to quickly respond to changing conditions. In the manufacturing context, Adler et al. (1999) describe the contradictory requirements from flexible and efficient systems; the latter require high levels of standardization and formalization where as the former need relatively more fluid processes of mutual adjustment. An ambidextrous organization is one that can balance the and simultaneously pursue such contradictory requirements; they can simultaneously explore and exploit, or be flexible and efficient, for instance (Benner and Tushman, 2003).

Recent literature has extended the concept of ambidexterity to the IS function. Vinekar et al. (2006) describe contradictory contexts associated with the use of agile and traditional systems development methodologies, and describe an ambidextrous systems development unit as one that has organizational structures, processes and tools required for both. There are typically two aspects to the operations of the IS function (Mark and Monnoyer, 2004; Peppard and Ward, 2004). The "supply" aspect deals with ensuring the delivery of IT services to support business functions. These include building and maintaining basic infrastructure such as servers, databases and networks, and running them efficiently and reliably at low costs. Resource allocation for these aspects is driven by targeted investments and expected operational improvements. The "demand" side has to do with helping the business innovate through the use of IT. It requires communicating with business unit leaders, identifying business problems and opportunities, experimenting with different solutions, risk taking, and creating business accountability for

IT projects. Resource allocation for demand side investments is driven by strategic considerations with long term horizons, and not necessarily by return on investment (ROI) considerations. Current thinking of CEO's and CIO's (Mark and Monnoyer, 2004) suggests that the IT function can best serve the product and process innovation needs of the organization when it is "ambidextrous", that is, capable of fulfilling both of these aspects of its operations.

3.5. IT/Innovation governance

Governance is the structure and process through which different work elements are coordinated and the inter-dependencies among them managed. In this context, IT/Innovation governance represents a firm's authority and communication patterns among innovators, those responsible for approving and managing innovation projects, and those responsible for the managing a firm's IT resources (Schwarz and Hirschheim, 2003; Weill and Ross, 2004). IT/Innovation governance draws from technical as well as human resources, and has a number of aspects to it. The first consists of defining integration and standardization requirements for IT infrastructure planning and security management (Bharadwaj et al., 1999; Weill and Ross, 2004). Decisions made at this level affect the tools and resources available to innovators. IT/Innovation governance defines the extent to which innovators have a say in these decisions. A second aspect includes the management of organizational units that have a stake in IT or research services, such as the central or corporate IS and R&D groups, as well as similar groups that exist in individual business units or functional divisions. A third aspect has to do with creating liaison positions and authority structures designed for allocating responsibility among the different stakeholders and for accomplishing key IT-related innovation tasks. These authority structures, also called "architectures" (Gordon and Gordon, 2000; Schwarz and Hirschheim, 2003), define IT service delivery mechanisms and the location of IT resources.

3.6. Business-IS linkage

A tight linkage between business and IS is often required for IT to be incorporated as an innovation into a product, service, or process. IS professionals need to work hand-in-hand with business leaders and, often, a company's customers and suppliers, to understand the operation and strategy of their company's business units sufficiently well to contribute to their innovation. In addition, business leaders need to understand the potential of IT to improve their products and processes; otherwise, they will be unwilling to invest in IT-based innovation. Many innovations that incorporate IT have been attributed to the intimate involvement of IS professionals in the business and the intelligent exchange of information between IS professionals and business leaders (see, for example, Abetti, 1994; McKenney et al., 1997).

Bassellier and Benbasat (2004) identify two kinds of business knowledge that IS professionals should have. First, organization specific knowledge includes knowledge about the organization, its strategic and operational goals and its critical success factors (Avital and Vandenbosch, 2000; Lee et al., 1995; Todd et al., 1995). It also includes knowledge of the different parts of the organization and ways in which they relate to one another (Nelson, 1991), capabilities for business problem solving, knowledge of how IT can be integrated with the business and understanding of how IT can contribute to organizational performance (Brown and Sambamurthy, 1999). Second, interpersonal and management knowledge includes the ability to lead, work in teams, use business vocabulary, and develop relationships with functional managers (Lee et al., 1995; Nelson, 1991). It also includes knowledge of "who knows what" in the organization, and the ability to access that knowledge from the relevant places (Joseph et al., 1996).

The business-IS linkage competency draws mainly from IS human resources, as well as intangible resources such as relationships with end users and a learning-oriented IS culture. Studies on innovation suggest that organizations where members access external and cross functional information and can adopt broad perspectives, experience greater innovation. (Kanter, 1982; Seely Brown, 2002; Utterback, 1971). As process innovation increasingly relies on effective partnerships between IS and other functions, it is necessary for IS professionals to understand and appreciate the role of IT in the context of the organization's processes (Nelson and Cooprider, 1996). This enables them to form partnerships with the departments, communicate with and understand their clients from functional areas, and participate in innovation decisions and activities (Feeny and Willcocks, 1998; Rockart et al., 1996). Tanriverdi (2005) observes that the closer the integration between IT and business in a firm's business units, the greater its cross-unit knowledge management capability.

3.7. Process modeling

A process model is an abstract representation of an existing or intended process. Because implementing new information systems often results in process change, IT specialists are usually trained in process modeling techniques (see Aguilar-Saven, 2004, for a review of these techniques) and tools, such as the Unified Modeling Language (UML) and the Architecture of Integrated Information Systems (ARIS). In addition, various software products exist to help implement these tools and techniques. A process modeling IT competency is a relatively low level competency that expresses facility and experience in the use of these tools and techniques for modeling processes.

A process modeling IT competency supports process innovation by providing structure to the redesign process and cognitive support for those involved in it (Sarker and Lee, 2006). It may also facilitate the flow of process knowledge among process experts, process designers, and IS professionals (Kalpic and Bernus, 2006). As such, this competency may depend on a company's competency in knowledge management and may both support and strengthen a company's competency in business-IS linkage. The process modeling competency draws from IS human resources and appropriate software resources.

4. Research methodology

We adopted a qualitative methodology (Miles and Huberman, 1994) and analyzed the adoption of two process innovations at one case study site to understand how the IS competencies influence innovation. We followed the methodological steps as suggested by Guba and Lincoln (2000) and Yin (2003). These included the development of a question schedule, data collection through interviews and secondary records, data analysis and revisiting interviewees for new information.

4.1. The study site and process innovations

The study site was Mercy Health Partners (MHP), a healthcare provider in the Midwestern region of USA and one of the largest healthcare organizations in the region. The organization has seven hospitals over a 20 county area in the states of Ohio and Michigan, and employs 7300 employees and 2140 medical staff. We selected MHP because of its reputation for innovation (please refer to Footnote 6), its proximity to one of the authors, and its willingness to participate.

In the Unites States, Healthcare Management Organizations (HMO's) work with insurance companies, hospitals, laboratories and physicians to provide medical services. Reports by the Institute of Medicine (IOM)[4] have identified two problem areas relating to the high cost of healthcare-(1) medical errors, such as errors in diagnosis and drug administration and (2) managing patient records. Consequently they have recommended significant changes in processes involving (1) prescribing, dispensing, administering and monitoring the effects of, medicines and drugs and (2) acquiring and storing patient health records.

In the healthcare context, innovations associated with management of processes and activities in the hospitals and clinics, such as those described above, are administrative/process innovations (Dewar and Dutton, 1986)[5]. MHP implemented two process innovations in its hospitals and facilities, during the period 2003–2006[6] As part of the first innovation, the company redesigned its order entry process, to incorporate electronic entry of orders for medicines and tests. In the old process, doctors would dictate their medication and testing orders into a machine, or write them by hand, for nurses and clinical staff to transcribe. The new process involved pointing and clicking on menus and selecting standardized orders, which was expected to reduce human error in writing, interpreting and transcribing. The second innovation involved the design and implementation of a process to electronically store and retrieve the clinical records of all patients who passed through MHP hospitals and facilities. Under the existing process, records for patients in individual hospitals and facilities were maintained separately, and were physically transferred or re-created in case of visits to more than one facility. In the new process, they would be stored and retrieved from a central location, accessible from any hospital or facility. We studied

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[4] The Institute of Medicine (IOM) advises the federal government and identifies critical issues in matters of medical care, research and education. The "Quality of Healthcare in America" project initiated by IOM in 1998 identified problems and high cost areas in the healthcare system. For example, health related records are stored with individual HMO's and there is no common "national" or even "regional" health record system for citizens. Consequently tests are repeated when patients change HMO's, leading to unnecessary costs. In this paper, we reference two reports "To Err is Human" (2000) and "Crossing the Quality Chasm" (2001).

[5] Innovations in diagnosis and treatment methods (such as remote surgery technology e.g.), are product/service innovations (Dewar and Dutton, 1986).

[6] A number of process changes are underway in many healthcare organizations. According to the Medical Records Institute's 2004 "Annual Survey of Electronic Health Record Trends and Usage", about 15% of respondent hospitals had been storing and retrieving laboratory and radiology information electronically for one year, and about 4% for two years. About 15% of responding healthcare organizations had been allowing doctors to enter their orders electronically, with clinical support such as alerts and warnings, for one year, and 9% had been doing it for two years. MHP was therefore one of the early adopters of some of these changes.

Table 4
Details of interviewees

Department	Organizational position	Professional affiliation
Clinical/ administration	Director of cardiology services at one of the hospitals	Hospital administration professional – senior/ middle management
	Chief academic officer	Physician – senior management
Clinical/information systems	Clinical information system specialist	Physician – senior/middle management
Information systems	Applications manager	IS professional – middle management
	Project manager	IS professional – senior /middle management
	Project manager	IS professional – middle management
	Network manager	IS professional – middle management
	Development/integration/application specialist	IS professional – junior/middle management
	Development/integration/application specialist	IS professional – junior / middle management
	Chief information officer	IS professional – senior management
Clinical	Hospital physician	Physician
	Hospital nurse	Nursing

the influence of the IS competencies at MHP in developing and implementing these two process innovations. At the time of the study, these two innovations had been implemented in two of the hospitals and were being developed and enhanced for implementation in the remaining facilities.

4.2. Data collection

Based on the discussions in Sections 2 and 3, we first developed a structured and open-ended questionnaire for conducting interviews. The questionnaire contained questions about the general background of the organization, the nature of the two innovations, the role and importance of innovation within the organization, and the role of specific IS competencies in the adoption of the two process innovations. Next, we contacted the Chief Information Officer of the case study site, who helped us identify subsequent interview subjects. We interviewed 12 people (from the IS department and other functional areas), from the corporate office and from three different hospitals, as shown in Table 4. We used the "snowball" approach, where specific interview subjects referred us to other people with relevant information. The interviews were conducted over a period of 7 months. Each interview lasted between 1 and 2 h. Some people were interviewed more than once, in instances where data analysis revealed a need for further clarification. Besides the interviews, we also referenced company reports, diagrams, meeting agendas and memos. External industry reports added further context to the data collected from internal sources.[7] In the next section we provide a description and analysis of the findings.

[7] Besides the reports by the IOM mentioned earlier, we also accessed results of the Medical Records Institute's survey titled "Survey on Electronic Health Records Trends and Usage for 2004", available online at http://www.medrecinst.com/uploadedFiles/resources/EHR%20SURVEY%20RESULTS-2004-Web.pdf.

5. Findings

In this section, we first provide background information that we collected about the IS department and IT infrastructure. We next describe the phases of the two innovation projects as revealed through the interviews and company documents. We then analyze the IS competencies and explain and illustrate how they facilitated the innovation projects.

5.1. IS department and IT infrastructure

The IS department at MHP, headed by the CIO, had four sub-groups. The "Technology" group was responsible for planning and maintaining technical infrastructure-servers, desktops, networks, and helpdesks. The "Applications" group looked after system analysis, applications development, workflow mapping, process transformation, and applications support. The "Project" group managed projects and did portfolio management and project accounting. The "Security" group was responsible for planning and implementing IS security management practices and regulatory compliances.

IS projects were approved by five committees representing five functional areas-physicians, clinical departments, ambulatory departments, financial departments, and corporate departments. Committee members included middle managers from the IS departments and the respective functional areas. Each committee was co-chaired by the vice president of the respective functional area and the CIO and reported to a higher level approval committee, the Executive Council. The members of the Executive Council included vice presidents from functional areas and the chief financial, operating and information officers.

The MHP facilities and hospitals were connected through metropolitan and wide area networks, with local area networks within each facility. Individual hospitals stored their own data for the "near term"; two data centers stored business applications business applications and "long term" data. An intranet-based corporate portal provided the front end for all applications.

5.2. Description of IS projects corresponding to process innovations

The two process innovations were implemented through two cross-functional systems, spanning nearly every clinical department. Each system consisted of a front-end application, integrated with back-end databases that pulled data from different departments. The first innovation was implemented through the **Computerized Physician Order Entry (CPOE)** system. The CPOE application enabled doctors, clinical technicians and nurses to enter, retrieve and administer medication and diagnostic orders for patients. The CPOE database contained information on all orders for each patient. The second innovation was implemented through the **Electronic Health Record (EHR)** system. The database for this system stored in one central location, the lifetime clinical records of patients, for tests, visits and hospitalizations. It could be accessed remotely or locally by physicians and nurses to access, retrieve and analyze records.

The CPOE and EHR systems were implemented through two projects, owned and managed by the IS department. The projects were executed primarily by project teams and supported by design committees consisting of physician and nurses. Each project was divided into three phases. In the first, the ***Planning and Developmental*** phase, the projects were approved and their scope finalized. This phase had three aspects. The first related to the **decision to adopt and implement the two process innovations**, and initiate the corresponding IS projects. The second involved **planning for structure related issues**, where structures such as committees, project teams and liaison positions involving the IS and other clinical departments were created. The third aspect was **planning for technology related issues** and consisted of developing specifications for the technical framework for the applications supporting these innovations, and planning for the required infrastructure.

In the second, ***Implementation and Testing*** phase, workflows and processes were developed and refined, application screens and paths to reflect the new processes were designed, front-end applications were integrated with back-end databases, and process flows and application screens were tested. This phase had four elements. The first one consisted of activities relating to **development, testing and troubleshooting of system prototypes**; these activities were the responsibility of the IS professionals, but required feedback information from users. The second was **development of additional features**, features that had not been originally planned, and requirements for which emerged as the project progressed. The third was **process re-design and improvement**, where the developed workflows were further refined based on feedback from designers or users. The final element involved **user participation and involvement** in the implementation. Given the scope of changes anticipated, this was important for preparing end users for the next phase.

The final, ***Training and Use*** phase had activities such as training of end users (clinical technicians, nurses and physicians) and formulating strategies and mechanisms for encouraging the use of the applications. This phase had three aspects. The first related to **encouraging the use of the new processes and systems, and reducing end user resistance to them**. The second involved **activities that prepared the organization for subsequent roll outs** in remaining hospitals and facilities. The third related to the **discovery and understanding of unintended and "higher" level uses** of the system, for further enhancing the effectiveness of the new workflows.

The two projects were executed simultaneously and their timelines phased over three years, for roll-outs in four of the seven hospitals in the organization. For the first hospital, the first phase was executed from November 2003 to May 2004, the second from March 2004 to September 2004, and the third from July 2004 to November 2004, with two months of overlap between successive phases. For the second hospital, the first phase began in June 2005 and the last ended in March 2006, an eight month period. Each phase lasted four months with two months of overlapping between successive phases. Project execution in the third hospital was scheduled between January 2006 and July 2006, and for the fourth hospital, between May 2006 and November 2006, with similar overlapping periods between successive phases.

5.3. IS competencies and how they influenced the innovation projects

To identify the IS competencies and analyze their influence on the different phases of the two process innovations, we coded the interviews and company documentation in two ways. First, we performed axial coding (Strauss and Corbin, 1998) based on the seven IS competencies in our research model. We grouped together interview data that related to each of the competencies (along the descriptions in Section 3), to identify the aspects of each IS competency as present at MHP. Data from company reports, meeting agendas

Table 5
IS Competencies that influenced the process innovations

IS competencies	Aspects	How they facilitated the process innovations
Knowledge management	1. Use of the corporate portal for pooling, posting and disseminating information about projects 2. Logging and sharing of project plans, logs, minutes among project team members 3. Use of SharePoint for sharing and searching through project related files by project team members 4. Systematic logging and storing of knowledge, feedback and suggestions from doctors, nurses and technicians, for easy access by project team members 5. Use of the corporate portal for disseminating information about similar process innovations at other healthcare organizations	Enabled the project teams to systematically store knowledge about the processes from different internal and external sources, and to access and disseminate the knowledge as required
Collaboration	1. Use of the corporate portal for communicating project schedules and problems to the organization and for soliciting user feedback and suggestions 2. Collaboration between IS professionals and user groups through regular meetings of the project teams with physician and nursing design committees. Use of Lotus Notes for developing ideas based on these meetings 3. Communication of concepts relating to the latest technologies and applications through "Lunch-and-Learn" education seminars conducted by IS professionals for other departments	Enabled collaboration and communication between process design and user groups so that workflows could be adequately captured and end users appropriately informed about project schedules and plans
Project management	1. Formation of cross-functional project teams for facilitating representation from all clinical departments affected by the process innovations 2. Project scheduling and planning for ensuring overlapping periods between different phases at each site and time gaps between project execution at different hospitals – to facilitate handoff between phases and assimilation of learning from one implementation site to the next 3. Regular project meetings for taking stock and identify necessary changes in scope and schedule 4. Use of project management software, Project Office, for tracking and managing project deliverables	Enabled appropriate project membership as well as time and resource management of the projects

(*continued on next page*)

Table 5 (*continued*)

IS competencies	Aspects	How they facilitated the process innovations
Ambidexterity	1. Appropriate (and different) criterion for approving "supply side" (regular maintenance and upgrades and relatively simple new acquisition related) projects and "demand side" (complex, strategic, innovation oriented and large scale change related) projects – to facilitate approval and evaluation of the two projects studied in this research	Enabled the firm to recognize the strategic importance of the innovations and apply appropriate long-term evaluation criterion
IT/innovation governance	1. Creation of liaison or "bridge" positions at the senior, middle and junior management levels. 2. Formation of dedicated project teams for ensuring better planning for and availability of resources 3. Technology and infrastructure standardization for ensuring technical compatibility among the different applications and systems which were part of the process innovations	Enabled the creation of structures and mechanisms for effectively managing technical resources and facilitating use buy in of the innovations
Business IS linkage	1. Business involvement of IS professionals • Inclusion of people with clinical background in the IS departments • Regular interaction between IS professionals and the clinical departments at ***all*** stages of the two process innovations • Handholding and support for end users • Strong professional understanding between the CIO and other members of the Executive Council 2. Business competence and knowledge of IS professionals	Facilitated user (IS) understanding and appreciation of the technical (business) aspects of the innovations, IS support for end users and top management support for the innovations

and memos was similarly grouped. We identified six groups or themes of data, corresponding respectively, to the first six IS competencies described in Section 3. Second, we performed open coding (Strauss and Corbin, 1998) where we analyzed the interviews and documents for descriptions where an aspect of a particular IS competency was related in some way to a particular phase of the innovation projects. In this way we identified instances where aspects of each competency facilitated or enabled the activities associated with different phases of the projects.

Brief descriptions of the aspects of each IS competency that we observed from the data are given in Table 5. Table 6 summarizes data from the progression of the three phases of the two projects for the first hospital. It lists the IS competencies row-wise, and activities within the three phases column-wise. The descriptions at each intersection

Table 6
How IS competencies facilitated the phases of the innovation projects

Project phase	Planning and developmental (November 2003–May 2004)			Implementation and testing (March 2004–September 2004)				Training and use (July 2004–November 2004)		
Important aspects and activities of each phase	Project initiation – Decision to adopt the innovations	Planning for structure related issues	Planning for technology related issues	Prototype development	Development of additional features	Process improvement	User participation and involvement	Encouraging process use	Preparing for roll outs in other hospitals	Advanced use
IS competence										
Knowledge management				Collecting and organizing inputs of project teams and end users to facilitate the development of prototypes			Creating awareness about projects and encouraging users to voice suggestions and concerns, thus securing user buy-in			
Collaboration				Collaboration among IS professionals and clinical departments for identifying system requirements	Collaboration between project teams and physician design committee for identifying requirements for new features					
Project management		Cross functional project team ensured representation and facilitated user buy in and participation						Regular project meetings resulted in prompt action on user feedback and allocation of resources for end user support	Time-slack between implementation at different sites helped assimilate learnings and solving problems prior to subsequent rollouts	
Ambidexterity	Project was approved based on strategic and long term, rather than immediate ROI related, criteria									

(*continued on next page*)

Table 6 (*continued*)

Project phase	Planning and developmental (November 2003–May 2004)			Implementation and testing (March 2004–September 2004)				Training and use (July 2004–November 2004)		
Important aspects and activities of each phase	Project initiation – Decision to adopt the innovations	Planning for structure related issues	Planning for technology related issues	Prototype development	Development of additional features	Process improvement	User participation and involvement	Encouraging process use	Preparing for roll outs in other hospitals	Advanced use
IT/innovation governance		Liaison positions and dedicated project teams helped anticipate and plan for resources needed for the projects	Infrastructure and technical standardization ensured interoperability of applications and systems that would be developed	Liaison positions facilitated correct understanding and representation of physicians' and nurses' workflows				Liaisons positions helped secure user buy in		
Business/IS linkage	IS professionals provided functional committees with information about the projects, as inputs to the adoption decision		Business competence of IS professionals provided solutions to technical and design issues	Application developers worked in the functional departments with end users to correctly understand and develop workflows	Application developers worked with physicians and nurses to understand technical requirements for new features Business competence of IS professionals helped the project teams understand the rationale for new features and identify unnecessary features which might lead to scope creep	Business competence of IS professionals helped them suggest process improvements for end users to consider		IS professionals were closely involved with user problems and provided handholding, training and support		IS professionals engaged with end users and educated them about additional application features

of a row and a column briefly describe findings that explain the influence of a particular IS competency on a particular innovation activity. We next present in detail data, illustrations, and interview quotes that expand on the descriptions summarized in Tables 5 and 6.

5.3.1. Knowledge management

There were five aspects to the ***Knowledge Management*** competency. First, the IS department used the corporate portal to post and pool information relating to important aspects of the two projects. The portal thus provided a central facility for knowledge sharing within the organization. Second, the project team and the physician and nursing design committees regularly logged and shared project documentation such as plans, logs and minutes of meetings, among themselves. Third, the teams and design committees used Microsoft SharePoint, for sharing, storing, and searching through project files. Fourth, feedback and suggestions from users (doctors, physicians and technicians) regarding problems was systematically stored, for easy access by project team members. Fifth, the IS department was aware of similar process innovations underway at other healthcare organizations and used the portal to disseminate related information.

During prototype development in the ***Implementation and Testing*** phase, this competence was instrumental in systematically collecting and organizing end user inputs during prototyping and trouble shooting. The IS department used the portal to collect feedback from end users about various aspects of the screens, features and workflows. There was also a "What's happening this week" section on the portal that contained information about important project issues and events. Users could thus keep themselves informed and prepared, and give suggestions to preempt further problems. One of the project managers said, "*We organized information about the projects [through the portal]. If users wanted to go out and look at it, we had different documents, different articles, we had timelines for the projects, so that they would know the important things*".

Further, this competency enabled user participation and involvement, also in the ***Implementation and Testing*** phase. Since the two process innovations impacted much of the day-to-day functions and workflows of the clinical environment, user participation and buy-in were critical to implementation and testing. The postings on the portal created awareness and interest among end users about the projects, so that they voiced their suggestions, ideas, and concerns. One of the nurses mentioned "*IT told us what going on-in the CPOE project, they told us about the order sets they were making, so we knew what they were working on*". This competency therefore facilitated user buy-in during this phase.

5.3.2. Collaboration

There were three aspects of the ***Collaboration*** competency. The first was the use of the portal. The IS department used the portal to communicate project schedules and problems to the rest of the organization. A "feedback" link was used for collecting feedback from end users about issues important to them. Second, meetings of the project team members, among themselves and with the physician and nursing design committees created means of collaboration between IS professionals, physicians, nurses and senior functional managers. Lotus Notes was used to organize and distribute ideas based on the discussions in these meetings. Third, there were educational meetings and seminars, organized by the

IS department and attended by IS and functional managers, where concepts and applications on industry relevant new technologies were discussed. One of the development specialists said of these meetings, "*If there is a new technology or application that we want to look at, we do a "lunch and learn" meeting, where we talk about it and discuss its uses in the clinical process*".

This competency helped in prototype development during the ***Implementation and Testing*** phase by facilitating collaboration between end users and IS professionals. It enabled people from the departments to communicate and work together, so that different perspectives and requirements could be integrated into the design of screens and workflows. The discussions during the meetings and seminars fostered collaboration among users, project members and system designers. Problems could thus be identified, discussed and solved in a regular and sustained manner, resulting in more comprehensive and useful inputs for trouble-shooting and prototype modification. According to the applications manager, "*We got a lot of cross pollination in these meetings. It helped everyone understand the problems better*." Additionally, there was a "feedback" button on every prototype screen that was developed. Physicians and nurses could use it to communicate to the project and design teams, information about problems with screens and workflows. This was especially useful in getting physicians' feedback on the prototypes of the "order sets" that the application team for the CPOE project developed. Physicians found it cumbersome to enter separately, medication and testing orders that usually went together. Order sets were pre-developed "bundles" of common medication and testing orders that physicians usually prescribed together. Instead of clicking and choosing different orders separately, physicians could thus have common "generic" order sets to choose from. An application manager said, "*It was critical to have physician input as to what order sets they wanted. The feedback buttons were frequently used.*"

This competency aided the identification of requirements for new features, also during the ***Implementation and Testing*** phase, through collaboration between the project teams and the physician design committee. This was especially effective in identifying order sets in addition to the ones that had initially been planned. "*The physicians from these committees designed some of the screens for the new order sets, and the IS team picked it up from there*". In another instance, there was a need for developing application logic for automatically calculating dosages to be administered. These requirements were understood through collaboration with the nursing design committee. The clinical specialist mentioned, "*There is constant back and forth, not only among the different parts of the IS department, but also between IS and the functions*".

5.3.3. Project management

The ***Project Management*** competency had four aspects: formation of a cross functional project team, project scheduling and planning, regular project meetings and the use of project management software. The projects were planned and scheduled such that there were time gaps between project execution at different sites, and overlapping periods of time for the different phases at each site. This ensured time for rectifying problems between rollouts at successive sites, and smooth transitions between the different phases at each site. Regular project meetings took stock of current situations and identified potential points for change on scope and time. The project teams met among themselves, as well as with end users and other committees. Project management software, Project Office was used to track and manage the projects and their deliverables.

As part of the planning for structure related issue during the ***Planning and Developmental*** phase, cross-functional project teams were formed. This ensured that all departments having a stake in the projects were adequately represented, and end users of the applications involved from the beginning. IS professionals in the project teams were the technical experts and the nurses, physicians, radiologists and technicians in the teams were the subject matter (process) experts. Therefore, both technical and functional aspects of the projects were addressed. The project manager of the EHR project said, "*We put this team together and all they did was EHR. It's got to be a dedicated team and that's all they [should] focus on. We actually went to the hospital directors and [asked them to] nominate people. We sent letters to physicians and asked for representation from each hospital. And we tried to mix specialties because we wanted to make sure everyone was represented.*"

This competency encouraged the use of the new processes during the ***Training and Use*** phase. Regular project team meetings enabled the project team to act promptly on feedback received from users. For instance, even after designing the convenience order sets, many physicians continued to use the verbal and written order entry systems. The project support team after consulting with individual physicians created more order sets, and made some changes to existing ones. One of the support people said "*We kept making [reasonable] changes that they asked for, to make it (the use) happen*". Moreover, the project team was able to sense impending support related resource requirements arising from the physicians' reluctance to use the technologies. For instance, the physicians tended to ask the nurses to perform the electronic order entry functions instead of doing it themselves. The nursing departments became overloaded as a result of the extra work. The project team deployed extra IS professionals to provide the required support. The project manager of the CPOE project said, "*We had to re-plan, change our own schedule and subsidize them more. Things like that, resource type things, training and retraining-they have all been roadblocks.*"

This competency also facilitated preparation for subsequent implementation in other hospitals, also during the ***Training and Use*** phase. The project schedules (time gaps between roll-outs in successive hospitals) and timelines enabled assimilation of learning from one roll-out, before commencing with the next one. After system implementation in each facility, the project team spent six to eight months documenting and understanding problems and assimilating key learnings, for improvements in subsequent roll-outs. One of the project team members said, "*We were at the first hospital for almost a year after the implementation, ironing out problems, getting feedback from users and making changes, until the bugs and user problems had been sorted out.*" Subsequent hospitals where the two projects were next implemented did not face these same problems.

5.3.4. Ambidexterity

The ***Ambidexterity*** competency was instrumental in enabling the organization to identify the strategic nature of the projects and their potential contribution to the organization's long term competitiveness, and apply appropriate criterion for evaluation and approval. There were two ways in which IS projects were approved by the company. First, routine "supply side" projects such as hardware and software replacements, maintenance and upgrades were approved through a bottom-up process. Project details and requests were generated by the user departments to the five functional committees. Project approval and funding criterion included costs, benefits, resource availability, and Return on Investment (ROI) considerations. Second, process innovation oriented, "demand side" projects, were approved through a top-down process. The Executive Council proposed these projects and approved them based on inputs and ideas from one or more of the committees. Approval criterion included long term and strategic objectives. The company was thus able to address the supply side by adopting analytical and structured evaluative criterion, as well as serve demand side by adopting more "intuitive" considerations when deciding on projects that were deemed strategic and involved large scale process innovation.

The two projects were approved as "demand side" projects, on the basis of strategic and long term considerations. The focus was similar to "*investing in R and D, not necessarily with short term, immediate objectives in mind, but as a matter of remaining at the cutting edge. The evaluation process was more intuitive*", as the chief academic officer mentioned. One of the project managers said in the context of the EHR and CPOE projects "*senior experienced people in the Executive Council got together and treated these as strategic projects. There was no clamor for a detailed ROI, they understood that it would not be feasible and would probably be counterproductive*".

5.3.5. IT/Innovation governance

There were three aspects to the ***IT/Innovation governance*** competency – creation of liaison positions, formation of dedicated project teams and technology standardization.

As part of the planning for structure related issues during the ***Planning and Developmental*** phase, liaison positions were created at the senior and middle/junior management levels. The Clinical Information System Specialist (CISS) was a "bridge" or liaison position between the physician side and the IS side at the senior management level. It was staffed by a physician who reported to the CIO. It was a broad, high-level interface between the IS department and other functional areas. Its primary role was to help physicians and clinical staff understand the benefits from the projects, and prepare them for anticipated changes. The incumbent started the initial dialog between the physicians, nurses, and the IS department, during this phase. This dialog facilitated a shared understanding by end users and developers, of what was being planned and how it could be done. It helped plan for end-user technical support. The CISS mentioned "*the way that physicians and nurses were going to be working would change. I work in the trenches, I am familiar with physicians' processes and I can translate, to make sure that both sides understand one another*". The CISS position thus helped create awareness about the planned systems, which was the first step in preparing physicians and nurses for significantly higher levels of IT use. The junior/middle management level liaison positions between the IS and functional departments were called "Departmental System Specialists" – they were IS professionals with clinical backgrounds, who worked within the departments. They were advanced IT users. Their role was to understand and convey to the project teams the requirements and problems of end users. In addition, there were two other physicians from the hospital, who spent four to five hours a week working in the IS department. One of the IS managers said, "*Getting the right, influential physicians on board from the very beginning, was key*".

As part of the planning for structure related issues, also during the ***Planning and Development*** phase, the creation of a dedicated project team for each project ensured the availability of resources. Each team was exclusively responsible for its particular project, for the three-year period during which the two innovation projects were rolled out in the different hospitals. The CIO said, "*Because of the team structure, we had the right resources dedicated to EHR and CPOE. Without those dedicated teams it never would have worked*".

Infrastructure standardization (which consisted of specifying the technical framework for the applications supporting these innovations, and developing the required infrastructure) was part of the planning for technology related issues in the ***Planning and Development*** phase. The project team members recognized that the innovations would span many processes and that the systems would involve multiple departments. They also realized that different parts of the envisaged systems would have to seamlessly "talk" with one another, to make data integration possible, and to minimize data "hand off" problems. This was important especially for the CPOE project, where orders for medication and tests[8] would be entered by physicians and managed and administered by nurses and pharmacists. Standardization of hardware and software platforms and vendors across hospitals ensured technical compatibility. One of the project managers said, "*We had one vendor and one standard for all hardware and software*." As a result, from the architecture and infrastructure point of view, integrated sets of workflows required by the CPOE could be implemented.

During ***Implementation and Testing*** phase, the liaison positions ensured that the workflows of physicians and nurses were correctly understood and incorporated into the prototypes by the system designers.

This competency encouraged the use of the new processes during the ***Training and Use*** phase, through liaisons. Especially with the CPOE, there was stiff resistance from the physicians to entering their orders electronically, and taking on what they perceived to be extra work that was not related to their direct activities. The role of the CISS was crucial here. Being a physician and a peer, he was able to speak to other doctors in familiar vocabulary and persuade them to use the applications. A second senior doctor liaised between the IS department and end users-she contacted influential physicians and nurses in her hospital and secured broad-based user buy-in of the new processes.

5.3.6. Business-IS linkage

Business-IS Linkage manifested itself in two ways–in the business involvement of IS professionals and in the business competence of IS professionals.

There were four aspects to the business involvement of IS professionals – inclusion of people with clinical background in the IS department, interaction between IS professionals (in the application teams for example) and functional managers, handholding and support for end-users and a good relationship between CIO and the members of the Executive Council. Clinical professionals in the IS department included clinicians, nurses, therapists, and clinical technical specialists. One of the applications managers said, "*One of the*

[8] Medication orders were physician prescriptions for medicines. Testing orders were physician prescriptions for diagnostic tests.

strengths [of the IS department] I think is that we have brought clinicians into the IT environment, with health care experience. It's been very difficult to find such people." Given their background, these people were interested and involved in the clinical processes. Interaction between IS professionals and functional specialists was accomplished through meetings of the project teams, physician and nursing design committees and the lunch-and-learn seminars.

As part of the project initiation activities during the ***Planning and Developmental*** phase, the clinical professionals in the IS department provided the clinical and ambulatory functional committees information about the new processes envisioned by the projects, thus facilitating their evaluation decision. The CIO's relationship with the members of the Executive Council created opportunities for discussion and dialog between the IS and business sides, on the strategic nature of the CPOE and EHR projects. This provided inputs for evaluating these projects and addressing concerns about the expected financial outlay and difficulty in assessing ROI. According to the CIO, "*the clinical environment is an information-gathering engine-every piece of clinical innovation that comes along has an IT component to it. One of my roles is to build relationships with the clinical folks, to hear [what they want to do] and to tell them how IT needs to get involved to make it happen*"

As part of the prototype development activities during the ***Implementation and Testing*** phase, the business involvement of IS professionals enabled the project teams to understand user requirements. For instance, while developing screens that would be used by the pharmacists, application developers spent time working in the pharmacy department, to correctly incorporate their functionalities, screens and workflows. They worked with the laboratory technicians to make sure that the relevant screens worked properly. One of the application managers mentioned, "*The application teams worked closely with the departments to understand and document current process flows, for developing prototypes*". Similarly, while developing additional features, the design teams spent 4–6 h every week with two senior physicians from the hospital to understand the new features and incorporate them into the screen designs. The Department System Specialists also assisted the development team understanding the requirements of the new features. User feedback from initial prototypes was thus quickly assimilated, leading to rapid turnaround on user requests for additional features. One of the project team members said, "*We developed model screens for new features and shared them with the physicians and nurses. We met very often, the to and fro exchange of errors and problems was very fast*". One of the physicians said, "*the turnaround time when we asked for new stuff was very quick. They listened to what we wanted to say.*"

Business involvement of IS professionals facilitated the use of the new processes, during the ***Training and Use*** phase. There was resistance to the use of the new processes and systems, especially from physicians and nurses. IS professionals provided handholding and support for addressing end user problems. They solicited user feedback on problems by speaking at different meetings. The application manager mentioned, "*The word is out there that we are involved. So people included us in meetings and told us their problems and plans. We include these learnings in the next implementation sites.*" As a result, users were more prepared to be patient through the problems associated with the initial use of the applications. The CIO mentioned, "*there is a lot of leveraging that IS has done to make it [the use of the portal for managing and communicating project related information] happen in terms of training, educating and talking to people.*" A group of five people from the IS department designed and conducted end user training for nurses, technicians and physicians to help them understand the new workflows and use the system. Individual meetings were arranged for those who were reluctant or unable to attend classes. CD based training material was also developed and distributed. One of the project managers mentioned, "*We met with some in their offices. We met with some in the lounges. We went to their meetings and offered the education. We also put our training videos on the portal for people to download*". Additionally, the IS department identified "super users" – those nurses who were early users of the system. They volunteered to train and help other users. One of the project team members explained, "*We have identified super users that help other nurses with the CPOE application. They are advocates of the application and have helped reduce resistance among nurses through their dialog and training*".

Teams of IS professionals called "redcoats" (who had prior clinical and nursing backgrounds) worked round the clock in the hospitals and laboratories to assist doctors and nurses in operating the computers or navigating the screens. In addition, network specialists provided maintenance, network connectivity and configuration support for hand held wireless devices used by nurses and doctors. These initiatives ensured technical support for end users, thus providing assurance and reducing their resistance to the new processes.

The business involvement of IS professionals facilitated the discovery and understanding of unintended and "higher" level uses of the system, also during the ***Training and Use*** phase, leading to increased workflow effectiveness. The IS department remained engaged with end users even after implementation, and developed user awareness of different aspects of the EHR and CPOE systems. As a project manager said "*we continued the conversation between IS and the functional areas – this threw up ideas for new uses*". For instance, one of the physicians said that he initially used the EHR application for accessing patient records online. He realized (after conversations with a Department System Specialist) that since the EHR and portal systems were integrated, he could simultaneously view patient records and images with other physicians and consult with them through instant messages about particular patient records. This reduced the waiting time for second opinions, specialist advice and referrals. The CIO said, "*After every new "use" that they learn, they discuss with us about other uses. It is like a virtuous cycle. They use, they find it beneficial, then they want to know more.*"

A second manifestation of the ***Business-IS linkage*** competency was the business competence of IS professionals. The IS professionals used their interaction with the business departments, and their familiarity with the clinical processes to observe and understand information flows and workflow connectivity. The CIO said, "*IS is able to observe the macro, connected, whole process, understand how things happen, and make suggestions.*" Interaction with physicians and nurses also enabled IS managers to learn the business vocabulary and develop relationships with key people in the different hospitals. They could thus identify specific areas where business knowledge resided, and knew how to access the knowledge, through these contacts.

While planning for technology related issues during the ***Planning and Developmental*** phase, the business competence of IS professionals was instrumental in providing solutions for technical and design issues. For instance, while planning for technical capabilities associated with electronic access and storage of radiology and other images, the EHR project team initially planned for capabilities for basic storage and access. Subsequent discussions of the project team with the IS department resulted in a decision to adopt "active" storage options, where images could not only be stored, but also modified and signed off electronically. According to the director of cardiology services at one of the hospitals, "*We decided that this was a more advanced and efficient way to go and the initiative came from IS*".

The business competence of IS professionals helped in the development of additional features during ***Implementation and Testing***. Because of their understanding of the processes and their associated vocabulary, the project team members understood the rationale for and content of the new features to be incorporated. They also convinced end users against additional features (in instances such features were not possible or desired e.g.), preventing unnecessary scope creep.

As part of the process improvement activities, also in the ***Implementation and Testing*** phase, the project teams suggested process improvements for end users to consider. For instance, when administering and managing medication orders electronically, nurses could not easily distinguish between orders that had been fully administered, partly administrated or not administered. One of the nurses said, "*they [IS application specialists] suggested color coding the orders on the screen. That helped a lot*." One of the applications managers said, "*Our transformation specialists – they often suggest improvements. Now, there are limitations to this as well. Some departments understand and appreciate that, and others do not encourage it. Depends on the relationships we have built*."

5.3.7. Process modeling

We did not find the explicit presence of the ***Process Modeling*** competency. There were two possible reasons for this. First, similar process innovations were being developed by other healthcare organizations. The broad aspects of the two processes were therefore available from industry literature and interactions with other similar organizations, which was an aspect of the ***Knowledge Management*** competency. Second, the particular details of the new processes and the related systems and applications for the first hospital were initially developed through discussions between the design teams and the user community, demonstrating an aspect of the ***Business-IS Linkage*** competency, as described in Section 5.3.6. Process features were refined for each subsequent hospital and the changes were incorporated at previous implementation sites. As one of the project managers explained, "*When we made the first build, we ensured that it would be reusable for the other hospitals. During implementation at the first hospital, we involved some nurses from other hospitals and ensured, for instance, that the screens would work for them as well*."

6. Discussion

Our interpretation of the results suggests the following key observations.

First, we find, to answer our research question, that a range of IS competencies facilitated different phases of the two processes innovations at MHP. Each IS competency had a number of aspects, as shown in Table 5, and these aspects facilitated one or more activities associated with the innovation projects, as shown in Table 6. The results provide a systematic and overarching way to understand the influence of IS on process innovation – by analyzing how particular IS competencies can facilitate process innovation. The findings also provides practice-related value – managers can use them to develop a "score card" for determining an organization's IS readiness for supporting process innovation by analyzing the extent to which relevant IS competencies are present. Such a score card can be used to determine gaps and deficiencies by identifying IS competencies that are absent or weak, and to point towards those that may need to be developed in the future.

Second, the IS competencies were not completely "orthogonal"; there were overlapping elements among them. For instance, the corporate portal was an aspect of the ***Knowledge Management*** competency as well as the ***Collaboration*** competency. The portal was used for disseminating information in the former, and for obtaining user feedback in the latter. To give another example, the formation of project teams was part of the ***Project Management*** competency as well as the ***IT/Innovation Governance*** competency. The cross-functional composition was an aspect of the former, while the fact that it was dedicated exclusively to the two projects was an important aspect of the latter. Such overlaps are not unexpected, since by definition, an IS competency is formed when IS and IT resources are combined in unique and non-imitable ways. Hence different IS competencies can have common aspects; however the ***combined set*** of aspects for each competency was substantially distinctive (as shown in Table 5) and influenced process innovation in unique ways (as shown in Table 6). We leave it to future research to measure the extent of overlap, perhaps using large scale surveys.

Third, leading from the observation above, the different competencies reinforced and strengthened one another. For instance, even though there was no explicit presence of the ***Process Modeling*** competency, aspects of the ***Knowledge Management*** and ***Business-IS Linkage*** competencies were used for developing the parameters and structure for the new processes. This finding is consistent with existing characterizations of the ***Process Modeling*** competency as described in Section 3.7. In another instance, when system features and prototypes were being developed, the ***IT/Innovation Governance*** competency was associated with the formation of dedicated, cross functional project teams and the presence of the liaison positions. The ***Project Management*** competency was responsible for encouraging interaction among members of the project teams, as well as between the project teams, the physician and nursing design committees, the liaison positions and other users, by developing the schedules for meetings and presentations. These three aspects-cross-functional project teams, liaison positions and regular meetings-strengthened the ***Collaboration*** and the ***Business/IS Linkage*** competencies, and reinforced their role in prototype development. Similarly, during implementation, the ***Business/IS Linkage*** and ***Project Management*** competencies reinforced one another, in addressing issues of user resistance and user support. In a similar way, the corporate portal served to pool and disseminate information about the projects and innovations, as part of the ***Knowledge Management*** competency. The availability of information made it easier for end users to evaluate and give feedback, thus strengthening the ***Collaboration*** competency.

Fourth, there could be negative fall outs of some of these competencies, for innovation activities. For instance, in the case of the ***Project Management*** competency, project management processes that are very detailed and structured, can act as a deterrent for end users initiating innovation projects. In this context, one of the clinical administrators mentioned, "*While the project selection process is predictable and transparent, there is sometimes too much paper work and too many meetings. Things can get very bureaucratic and cumbersome.*" The ***Business/IS Linkage*** competency can also pose problems, especially if user resistance to innovation is high. One of the application managers mentioned, "*Sometimes departments don't appreciate our getting involved and suggesting changes to processes* *because they might feel that their expertise is under threat, and that we are beginning to know too much about their workflows*."

Fifth, MHP was successful at its process innovations without demonstrating the ***Process Modeling*** competency. This finding may be context specific and may be further qualified by future research.

7. Conclusion

The ideas developed in this paper address an important theme in current IS research-the importance of understanding how firms can acquire business value from their IT (Bharadwaj, 2000; Peppard and Ward, 2004; Sambamurthy et al., 2003; Wade and Hulland, 2004). We have used the RBV to develop an integrative, competency-based framework for identifying how IS can influence process innovation success. To briefly summarize our findings, IS competencies in Knowledge Management, Collaboration, Project Management, Ambidexterity, IT/Innovation Governance and Business-IS Linkages affected the conception, development and implementation of process innovations. Some of these competencies reinforced and strengthened one another. In this context, the paper, in explaining how these IS competencies facilitate process innovation, suggests that organizations can enhance the contribution of their IS in their innovation efforts by developing and strengthening relevant IS competencies.

The paper also reinforces current practitioner thinking (Koch, 2006), which suggests that one of the most compelling emerging organizational roles of IS is that of increasing participation in and potential leadership of business innovation, especially process innovation. In this context, our findings provide a backdrop against which practitioners can evaluate their organizations' to (1) assess the readiness and ability of their IS to facilitate process innovation and (2) identify those IS competencies that are missing or need improvement.

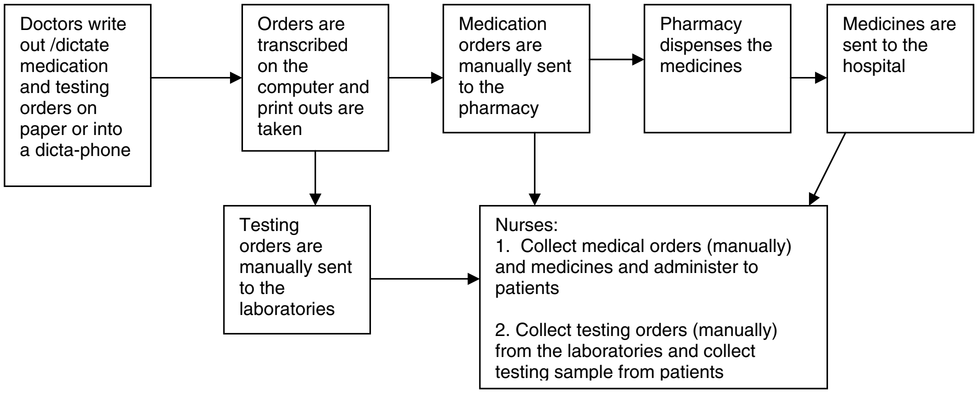
The findings presented here should be considered in the light of some limitations. First, they are based partly on post-event examination of data, and partly on real-time observation. For instance, we observed some of the events in the third phase, and relied on interviews and company documents for the first two phases. The findings can be refined by research that looks at longitudinal case studies following particular innovations through in real time. Second, the nature of the link between IS competencies and process innovation is context specific and is hence likely to play out differently in different organizations and industries; extensions of the analysis described here to other contexts must taken this into account. Multiple case studies in different industry sectors and organizational settings will be very relevant in expanding on what we have reported in this paper. Third, the IS competencies studied in this paper may not be the only ones that can affect process innovation; there are others that may influence process and product innovation.

There are a number of questions that future research is likely to find important. For example, are particular competencies more important than others, for specific phases and activities? Should specific competencies be developed together, to benefit from reinforcing effects? Under what conditions do particular IS competencies become indispensable to innovation? What are some of the best practices for strengthening the links between IS competencies and product/process innovation? We believe that this paper provides an approach for understanding the links between IS competencies and process innovation in an organization, and it is our hope that future studies will use the findings to investigate these questions.

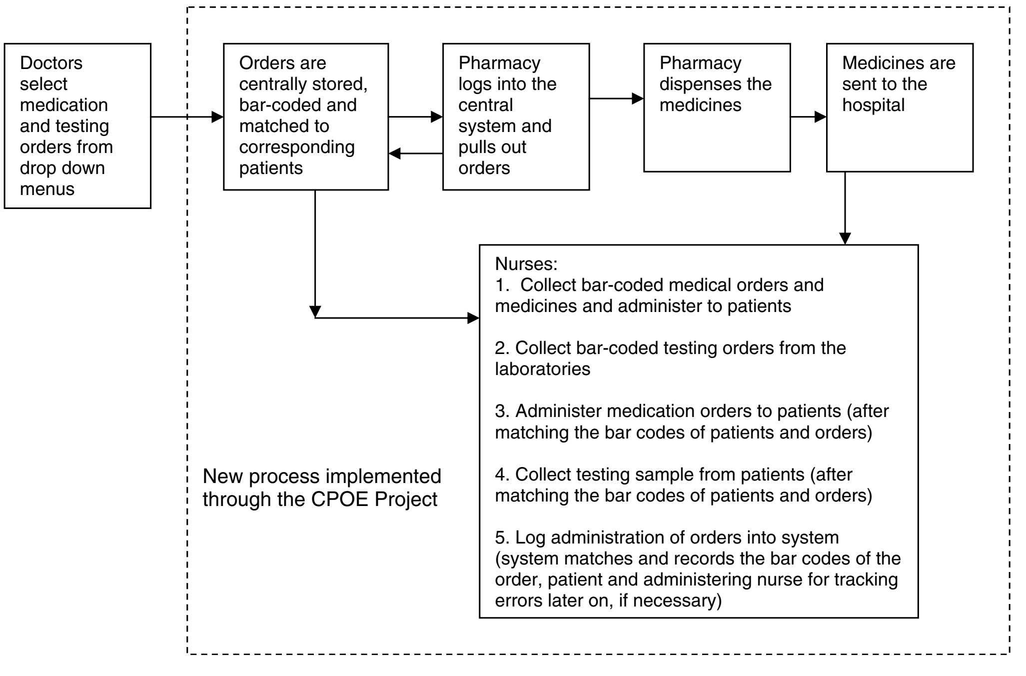
Appendix A. Process diagrams: old and new processes for the two process innovations

1. Physician Order Entry Process

Old Process – Manual System for Entering and Administering Orders

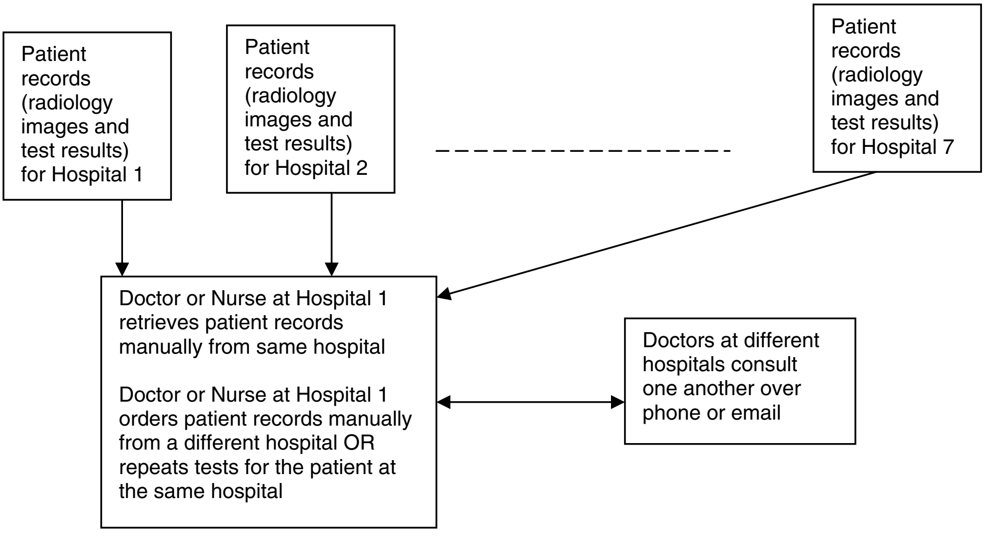


New Process – Computerized Physician Order Entry System

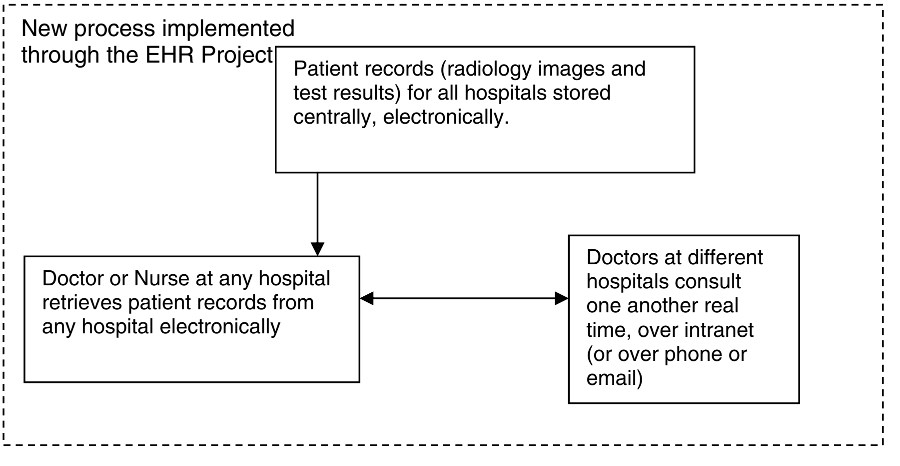


2. Electronic Access to Patient Health Records

Old Process – Patient health records stored in different facilities



New Process– Patient health records stored and accessed centrally



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