THE EFFECT OF IT PROCESS SUPPORT, PROCESS VISUALIZATION AND

PROCESS CHARACTERISTICS ON PROCESS OUTCOMES

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Business process re-engineering (part of the Business Process Management domain) is among the top three concerns of Information Technology (IT) leaders and is deemed to be one of many important IT leveraging opportunities. Two major challenges have been identified in relation to BPM and the use of IT. The first challenge is related to involving business process participants in process improvement initiatives using BPM systems. BPM technologies are considered to be primarily targeted for developers and not BPM users, and the need to engage process participants into process improvement initiatives is not addressed, contributing to the business-IT gap. The second challenge is related to potential de-skilling of knowledge workers when knowledge-intensive processes are automated and process knowledge resides in IT, rather than human process participants. The two identified challenges are not separate issues. Process participants need to be knowledgeable about the process in order to actively contribute to BPM initiatives, and the loss of process knowledge as a result of passive use of automated systems may further threaten their participation in process improvement.

In response to the call for more research on the individual impacts of business process initiatives, the purpose of this dissertation study is to understand the relationship between IT configurations (particularly process support and process visualization), process characteristics and individual level process outcomes, such as task performance and process knowledge. In the development of the research model

we rely on organizational knowledge creation literature and scaffolding in Vygotsky's Zone of Proximal Development, business process modeling and workflow automation research, as well as research on the influence of IT on individual performance.

The theoretical model is tested empirically in experimental settings using a series of two studies. In both studies participants were asked to complete tasks as part of a business process using different versions of a mock-up information system. Together, the studies evaluate the effect of IT process support, process visualization and process complexity on process participant performance and process knowledge.

The results of the studies show the significant influence of IT process support on individual process outcomes. The studies indicate that task performance does increase but at the cost of users' process knowledge. Process visualization however is shown to enhance user's process knowledge in the event of no formal process training while having no negative impact on task performance. The key contribution of this research is that it suggests a practical way to counteract potential negative effects of IT process automation by converting the use of the information system into a learning experience, where the IT itself acts as a scaffold for the acquisition of process knowledge. The results have practical implications for the design of workflow automation systems, as well as for process training.

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CHAPTER 1

INTRODUCTION

Background

IT today is in the business of business process change
Luftman & Ben-Zvi

In their annual survey of Information Technology (IT) leaders, the Society for Information Management (SIM) investigated management concerns during the final quarter in 2011: business agility and business process re-engineering were among the top three concerns. Business process re-engineering (BPR) went from being ranked 18th several years ago to 5th place in 2010, and 3rd in 2011 (Luftman & Ben-Zvi, 2011). BPR is deemed to be one of many important information technology leveraging opportunities to reduce costs.

BPR and business agility are parts of the of business process management (BPM) domain. BPM is defined as a "comprehensive system for managing and transforming organizational operations" and has emerged as a product of process improvement efforts (Hammer, 2010, p. 3; Harmon, 2010). IT plays a central role in enabling implementation and automation of processes that span the organization, with added benefits of increased communication, real-time monitoring and visibility (Majchrzak, 2008; Magal & Word, 2009). IT has also been credited as being the driving force for BPR. IT not only supports operational activities, but also aids in analyzing current and future processes (Sarkis & Sundarraj, 2008; Davenport, 2010).

Two major challenges have been identified in relation to BPM and the use of IT. The first challenge is related to involving business process participants in the process

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improvement initiatives using BPM systems. The second challenge is related to potential deskilling of knowledge workers when knowledge-intensive processes are automated and the process knowledge resides in IT, rather than human process participants.

The fact that BPM technologies are considered to be primarily targeted for developers and technologists and not BPM users is the source of the first identified challenge. It is also the basis of the business-IT gap problem where the end-users are neglected although they are the prime users of BPM systems (Dreiling, 2010). BPM has been treated as a tool and not an opportunity to introduce higher quality standards by way of focusing on end-user communities and exploiting the potential of IT to enhance a user's experience to further elevate organizational performance. While organizations have benefited from the "business process enablement" capabilities of IT (Raghu & Vinze, 2007), they have neglected the impact it might have on employees.

The second identified challenge is centered on the fact that although IT is known to be a great enabler for overall productivity, it often has had a less favorable impact on employees within different organizations. Historically, the intensified efforts of automation have turned IT into receptacles for larger and larger portions of an organization's operating knowledge and is considered responsible for the phenomenon of deskilling (Attewell & Rule, 1984; Zuboff, 1988). That concern is still found to be relevant in today's world as described by Vance (2012) in a *Bloomberg Business Week* article titled "The End of Free Will." Steiner's *Automate This* book (2012) portrays computer algorithms as taking over the thinking and analysis of our world's most complex problems, from algorithms that trade better on Wall Street to the ability to spot

cancerous tumors better than highly trained physicians. Previously, deskilling trends were considered to only affect lower-level employees while smart and innovative individuals were thought to be safe from the threat of computers taking over their jobs. Steiner (2012) warns that our past assumptions about computers not being able to innovate and create do not hold true today.

Here, I recognize that the identified challenges are not totally separate issues. The concern is that organizational knowledge now largely resides in information systems, rather than being absorbed by users as a result of passive use of automated systems. This impacts employees that need to gain this organizational knowledge if they are expected to be potential contributors to BPR efforts because they are process performers (Hammer, 2010). For successful process change efforts to occur there needs to be a comprehensive and sound understanding of processes by organization employees. Traditionally, management has exploited the automating capacity of technology rather than the informating (Zuboff, 1988). Using IT to disseminate process related knowledge and know-how within the organization for potential process improvement efforts is one way of using IT's informating capacities.

Interestingly the individual consequences of business process automation have not been widely addressed in business process research. Much of business process research has investigated organizational level effects (Venkatesh, 2006). Furthermore, because of their broad scope, process improvement initiatives have also usually been studied at the organizational level (Antonucci, 1997; Venkatesh, 2006, Markus & Grover, 2008). While providing valuable insights, such studies do not delineate the effects of specific technology configurations on individual level process outcomes.

Consequently, a call was made for research into the impacts of business process change and transformation on employees and the potential steps that organizations can take to mitigate any negative effects (Venkatesh, 2006).

Problem Statement

It has been recognized that knowledge about business processes within the organization resides with the employees that perform the processes (Dreiling, 2010). Such business process knowledge is considered an important competitive factor for organizations (Zuboff ,1988; Kock, McQueen, & Corner, 1997). People who work with the processes, process performers, need an overall understanding of such processes for effective performance (Hammer, 2010). However, there is little research regarding the effects of process automation on the individuals' process knowledge and performance (Venkatesh, 2006). In response to the call for more research on the individual impacts of business process initiatives, this dissertation research seeks to examine effects of IT on individual process knowledge acquisition and individual process-related performance. The purpose of this dissertation study is to understand the relationship between IT configurations (particularly IT process support and process visualization) and process characteristics and individual level process outcomes, such as task performance and process knowledge.

This study aims to answer the following research questions:

- o How does IT process support influence individual level process outcomes?
- o How does process visualization influence individual level process outcomes?

o   How do process characteristics influence individual level process

outcomes?

o   How do business process characteristics influence the relationship between

IT process support, process visualization and process outcomes?

In the development of the research model I rely on organizational knowledge

creation literature (Nonaka, 1994; Alavi & Leidner, 2001) and scaffolding in the zone of

proximal development (Vygotsky, 1978; Wood, Bruner, & Ross, 1976), business

process modeling and workflow automation research, as well as research on the role of

IT on individual performance.

Purpose and Contribution

This dissertation aims to investigate the influence of IT process support, process

visualization and process complexity on individual level process outcomes of IS users in

terms of performance and process knowledge acquisition. The study is expected to

have both theoretical and practical contributions. The theoretical contributions of this

research are three-fold. First, this research helps fill the gap in process improvement

literature by examining individual level outcomes of process automation. Second, by

focusing on the knowledge outcome, this research makes a step towards a closer

integration between workflow automation and process improvement research and

research in organizational knowledge management. Third, this study contributes to

research on data visualization by suggesting that IT-based visualization can be used as

a scaffold for organizational learning.

From the practitioner perspective, this research provides insights for both business process management and knowledge management community. The study offers insights to the BPM community by addressing the challenge of involving process participants into process improvement initiatives. The results offer further understanding regarding business process knowledge in relation to the deskilling effect of automation. By examining the role of process visualization, this research provides useful insights to the designers of business process management systems and workflow management systems. Furthermore, the study offers suggestions to the knowledge management community on how organizational learning can be improved through the use of IT. Specifically, it highlights the IT capabilities of providing scaffolding for individual knowledge acquisition through visualization.

Research Design

The theoretical model developed in this dissertation is tested empirically in experimental settings, using a series of two studies. Study 1 is used to test the overall theoretical model, whereas Study 2 is used to test a subset of the relationships included in the model under modified experimental conditions. In both studies participants were asked to complete tasks as part of a business process using different versions of a mock-up information system based on their assigned experimental treatment. Participants were then asked to complete a survey used to capture process outcomes. Together, the studies aim to evaluate the effect of IT process support, process visualization and process complexity on process participant performance and process knowledge and evaluate the moderating effect of process complexity on the

aforementioned relationship. Pilots of the experiment were previously conducted to evaluate the process and the related survey items.

Organization of the Dissertation

The remainder of this dissertation is organized in the following manner: Chapter 2 includes a review of related and relevant literature on business processes, IT support and process outcomes along with the related theoretical basis of this study. The research model and hypotheses are also presented. Chapter 3 includes a description of the research study. Specifically, the experimental procedures, experimental manipulations and research instrument development and validation are described. Chapter 4 discusses the data analysis results. Chapter 5 provides discussion and interpretation of the findings, contributions and conclusions.

CHAPTER 2

LITERATURE REVIEW

This research study draws on two distinct bodies of research: (1) business process and information technology (IT) research and (2) research on individual learning and cognitions. First I present the current state of research and practice on business process management and provide an overview of key business process related concepts. I then discuss the role of IT in supporting business processes, as well as the effect of IT on some of the key business process outcomes. In relation to the second research stream, I start by discussing the concept of knowledge in organizations and the role of individuals in the creation, acquisition and dissemination of such knowledge. I then discuss the role of human cognitive processes that are related to such knowledge creation, acquisition and dissemination. I specifically emphasize approaches to enhancing individual learning through the use of visualization, maps and scaffolding.

Defining Business Processes

I begin by defining the central element of this study, the business process as "a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action" (Davenport, 1993, p. 5). Business processes are also defined as "structured sets of work activity that lead to specified business outcomes for customers" by Davenport and Beers (1995, p. 57). From the organizational performance improvement perspective, business processes

have also been defined as "complex systems of human activities that are designed and improved to create value for the customer of the process" (Latva-Koivitso, 2001, p. 2).

Business Process Management Practice and Research

Business process management (BPM) is considered to have originated in the work of Shewart and Deming on statistical process control, total quality management, Six Sigma, and the concept of business process re-engineering (BPR) introduced by Hammer (1990) (as cited in Hammer, 2010, p. 3.). Notably, in BPR, business processes were redefined to mean "end-to-end work across an enterprise that creates customer value" (Hammer, 2010). The management styles of the 1980s and 1990s placed more value on overall production and performance of the firm which has contributed to the rise of process awareness (Harmon, 2010). The understanding of how work was done, rather than what was done, has become more prominent in the ultimate search for innovation and performance (Davenport, 1993). During the 1990s and 2000s, the shift to a functional view of any organization became the norm and business processes were at the center of these views. Some have even stated that "we are indeed in the age of the process" (Hammer, 2010, p. 16). This led to the birth of BPM, which is defined as "a comprehensive system for managing and transforming organizational operations" (Hammer, 2010, p. 3). The concept was considered to be a solution to the rapidly changing business environment of the 21st century. Organizations could not depend only on the automation of business processes to boost performance, but they also needed to consider the improvements that could be made to their processes to respond to market demands in a timely manner (Hammer, 1990).

In a review of what BPM can offer organizations, BPM expert, Michael Hammer illustrates that proper management of processes within organizations can yield benefits associated with lower costs, higher performance and increased quality (Hammer, 2010). However, organizations need to develop and utilize two key capacities: process enablers and enterprise capabilities (Hammer, 2007). Process enablers include a comprehensive process design, knowledgeable performers, responsible process owners, supportive infrastructures and balanced process metrics. Additionally, BPM is considered to be comprised of six core elements: strategic alignment, governance, methods, information technology, people and culture (Rosemann & vom Brocke, 2010). Human capital can be thought of as both a core element and a necessary enabler of BPM and thus warrants attention.

Business Process Representation and Modeling

Modeling business processes has long been considered critical to understanding and designing effective business processes and IT solutions. Formal specification of a business process is important as it helps eliminate variations that are due to individuals executing the process (Gribbins, Shaw, & Shaw, 2006) and IT is critical in such formal specification. Petri nets and process maps are among the more popular approaches to process modeling.

Petri nets are directed graphical and mathematical modeling tools used for describing information processing systems which allow for concurrent, distributed, and/or parallel processing (Murata, 1989; Ouyang, Adams, Wynn, & Hofstede, 2010). Petri nets are considered a powerful communication tool for both practitioners and

theoreticians for the creation of models that are both methodical and realistic. Petri nets are composed of places and transitions, which are connected with arcs. Tokens are used to model the flow within the system. Workflow nets (WF-nets) are a subset of petri-nets and offer valuable representation, validation and verifications of workflow procedures (van der Aalst, 1997). Workflow procedures specify both the set of tasks and the order in which they should be executed to process cases successfully (van der Aalst, 1997). Petri-nets are widely used in process modeling and simulation.

Standards in BPM

Business process modeling notations were developed as a means of standardizing business process modeling. The importance of having set standards in BPM is related to the need for tool interoperability, which enables easier transfer of processes from one platform to another (Leymann, Karastoyanova, & Papazoglou, 2010). For example, development of workflow management systems has long been constrained by the lack of good standards for business process modeling and the enforcement of excessive constraints on process logic (van der Aalst, 1997). Furthermore, organizations may have a need to create a "best of breed" from the available BPM vendors and standards enable them to pursue this strategy (Leymann et al., 2010). Additionally, business processes span several organizational units which may each have their own specialized BPM components from different vendors. BPM notation standards allows for integration and reuse of components and skills.

The business process modeling standard, BPMN (Business Process Modeling Notation), distinguishes between the following key elements of business process

specification: activities, control flow, gateways, message flow, and events (White & Miers, 2008). Specialized graphical symbols are used to specify and describe a business process. The main components of BPMN are flow objects and sequence flow. Flow objects are comprised of activities, events and gateways. While sequence flows represents the connection between the flow objects. One way for organizations to gain competitive advantages is to use business process modeling techniques and languages such as Business Process Execution Language (BPEL). This enables them to create business processes in a way that describes the logic of the transactions (Muketha, Ghani, Selamat, &Atan, 2010).

Process Complexity

While all business processes can be specified in terms of the key elements, they differ in terms of a number of features including process uncertainty, variability, time-criticality, load (Schober & Gebaur, 2011), process complexity (Gribbins et al., 2006) and variable process measures (Nissen, 1998).

Complexity is an inherent characteristic of business processes that needs to be measured and controlled since business processes tend to grow and become more complex over time specifically when new activities are added (Muketha et al., 2010). By definition complexity refers to "how difficult an entity is to understand" (Muketha et al., 2010, p. 1336) or the sensation of "the difficulty in analysis and synthesis of a given activity" (Latva-Koivitso, 2001, p. 4).

Process complexity is new to the business process domain and the need for more research into process complexity is recognized (Muketha et al., 2010). Many of

the existing conceptualizations of process complexity and associated metrics have been adopted from software development and engineering literature (Cardoso et al. 2006; Gruhn & Laue, 2006). The use of metrics within the area of software development has helped designers and management quantify success and improvements to make better decisions concerning the software (Muketha et al., 2010). Having defined complexity metrics would enable designers of processes to know how much allowed values of complexity are tolerated and adjust complexity levels accordingly (Latva-Koivitso, 2001).

Latva-Koivisto (2001) offers the following criteria for a good business process complexity metric: valid, reliable, computable, easy to implement, intuitive and independent of other measures. Because business processes include different types of elements (splits, joins, resources, data, etc), no single metric for process complexity can exist (Cardoso et al., 2006). Therefore, complexity has been defined in terms of activity complexity, control-flow complexity, data-flow complexity and resource complexity. Activity complexity is based on the LOC (Lines of Code) metric from software development and measures the number of activities in a business process. It only considers length (size) of the process as the main complexity factor. Another view considers counting control-flow elements rather than activities since control-flow affects the execution sequence of the activities (Cardoso et al., 2006).

Complexity is used as a basis for process categorizations into standard, routine or non-routine (Lillrank, 2003). Standard processes, the least complex of the categories, employs binary logic in acceptance tests of their pre-determined input. Limited variation exists with this type of process. Routine processes have more variety with two or more alternative output. Non-routine processes are characterized by unknown sets of input

and output and to be executed correctly may require interpretation and heuristics from knowledgeable employees. This business process complexity categorization was used in the investigation of the effort required for standardization of business processes (Schafermeyer, Rosenkranz, & Holten, 2012).

The inherent characteristics of standard, routine and non-routine processes as classified by Lillrank (2003) offer a measure of business complexity. Therefore, complexity of a business process is a function of previously agreed metrics of number and variety of activities and related dynamics (Schafermeyer et al., 2012; Lillrank; 2003; Karimi, Somers, & Bhattacherjee, 2007; Cardoso, 2006). Process complexity is of particular interest to this research study, as it is likely to influence the relationship between process support by IT and process outcomes.

The Role of IT in Business Process Management

IT investment impacts have been judged to be better measured at the process-level because that is "where the first-order effects of IT are often realized" (Jeffers, Muhanna, & Nault, 2008, p. 3). It is recognized that technology, a combination of tools and techniques that help transform data into organizational inputs, has been an important driver of organizational productivity and efficiency (Edelman, 1981; Daft & Lengel, 1986). During the early 1980s, the automation of processes was done with a focus on the minimization or elimination of human intervention for higher productivity. For example, a dental claims operation office was able to achieve productivity gains of up to 40 percent within a year of automation (Zuboff, 1988).

During the 1990s and early 2000s, IT development emphasized data-driven approaches with the focus on the storage and retrieval of information. Data modeling was considered the basis for building information systems (van der Aalst, 2002). BPM as a modeling trend shifted the focus to processes because process change is more easily adapted through process orientation rather than through data orientation.

BPM has more recently become a popular approach to the implementation and integration of large-scale information systems. It is implemented either through a separate BPM system (BPMS) (e.g. workflow management systems) or integrated into domain specific applications in the form of a module within ERP systems (Cardoso et al., 2006). Workflow management systems (WFMS) are centered around a business process and are defined as being the operating system of administrative organizations and, through the use of dedicated software, are capable of defining, creating and managing the execution of workflows (van der Aalst, 1997). Furthermore this class of systems is capable of interpreting process definitions, interacting with workflow users with or without the presence of other IT applications (van der Aalst, 1997). More than 250 WFMSs were on the market over a decade ago and the primary focus of such systems was on process automation. The more recently developed BPM systems look to provide analysis and management support (van der Aalst, 1997; van der Aalst et al., 2011). Unfortunately, these systems do not verify the correctness of the process models that drive them.

Process-aware information systems have recently emerged as software solutions that display "explicit awareness for the execution of business processes" (Rosemann & vom Brocke, 2010, p. 113). Workflow management, which involves the automation of

business processes and includes both people and software applications, is one instantiation of process-aware information systems (Ouyang et al., 2010).

Within BPM, IT is able to support both organizational and inter-organizational business processes (e.g. end-to-end linking of different organizational supply chains) (Mooney et al. 2001). IT has also been credited with the ability to create new process design options (Attaran, 2004). Automated business processes can be designed through different perspectives such as a process perspective for ordering of tasks (control-flow), information perspective related to how data is incorporated (data perspective), or a resource perspective which is related to organizational roles and resources (van der Aalst, 2002). The control-flow (or process) perspective is concerned with the ordering of activities and includes the flow of execution control through sequence, choice, parallelism and synchronization. This perspective is enhanced by the data-perspective that incorporates business and processing information such as documents or other activity objects. Finally, the resource-perspective contributes information regarding human and device roles and responsibilities associated with activities (Kiepuszewski et al., 2002). The different perspectives work together to provide a view of how a workflow is specified. However, the control-flow perspective is considered to be a determinant of the effectiveness of a workflow language because the other perspectives are layered on top (Kiepuszewski et al., 2002).

IT is also credited with enabling organizations to embed analytics into business processes (Davenport et al., 2010). This generates the needed competitive advantage for an organization because embedding analytics into business processes makes analytics a routine part of doing business. This enables the organization to implement

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new insights with the help of technology. Many software vendors have addressed this need by embedding analytics into their products such as ERP vendors that have embedded best practices into their business processes (Davenport et al., 2010).

Building on the notion of support in extant IS research, I define IT process support as the ability of the information system to structure individual actions in terms of individual activities, control flow, event, message flow and gateways. The notion of IT support is well established in research on Decision Support Systems (DSS) and group support systems and usually refers to the ability of IT to facilitate decision making or group communication (Turbin & Watkins, 1986; Mao & Benbasat, 2000; Speier & Morris, 2003). IT process support has emerged to include different paradigms, specification standards and tools which aim to achieve effective results for the organization (Mutschler et al., 2008; Ouyang et al., 2010). Business rule support has been crucial for policy implementation in organizations (Harmon, 2010) while control-flow support, the sequential ordering of tasks in a process, is considered vital for effective execution (van der Aalst et al., 2003; Ouyang et al., 2010).

Process Improvement Initiative Outcomes and the Role of IT

Process-oriented studies of IT business value have presented potential process outcomes such as: (1) the automational effects where IT derives its value as being a substitution for labor and being a cause for a reduction in cost; (2) informational effects where IT plays a role in storing, processing and disseminating information; (3) transformational effects where IT plays a role in facilitating and supporting process innovations (Mooney et al., 2001; Karimi et al., 2007). This study investigates two types

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of process outcomes: automational effects in the form of performance gains and informational effects in regards to process knowledge.

Performance

IT is credited with having a broad and multi-faceted impact on organizations (Torkzadeh & Doll, 1999). The successful implementation of information systems has been traditionally measured by the impact it has on different levels of the organization including the individual level. The improvement of task productivity for individuals in terms of time, quality and usefulness are a central theme of IT impact at the individual level (Torkzadeh & Doll, 1999). Furthermore, individual productivity is considered one of the individual-level impacts of IS success (Gable et al., 2008). Individual impact is defined as being "a measure of the extent to which (the IS) has influenced the capabilities and effectiveness, on behalf of the organization, of key-users" (Gable et al., 2008, p. 389). It includes improved executive efficiency and task performance. Other identified individual level impacts are learning, awareness/recall and decision effectiveness.

Within the decision support systems literature, performance is conceptualized by an individual's perception of decision accuracy and decision time. Both of those constructs can be considered to be instances of efficiency and effectiveness variables that are judged to be successful performance indicators (Swink, 1995; Speier & Morris, 2003; Paul et al., 2004). Decision performance, conceptualized as decision accuracy and decision time, was considered to be the primary outcome of a study that was concerned with comparing text-based query interfaces to visual query interfaces while

varying task complexity as well as individual spatial ability in a DSS (Speier & Morris, 2003).

Within the domain of business processes, process performance has also been studied in relation to process standardization efforts (Munstermann et al., 2010) where process performance is measured quantitatively through the dimensions of process time, cost and quality.

Process Knowledge

Within the knowledge management literature, business processes have been considered to be an excellent delivery medium of knowledge. Information about the process and the execution of it are considered valuable organizational knowledge. Jung, Choi, and Song (2007) state that traditionally BPM has addressed different aspects of process design and execution, but it has not addressed issues related to process knowledge management. They define process-related knowledge as "a knowledge set created and used within a business process. General explicit knowledge of traditional knowledge management is summarized from the point of the process perspective" (Jung et al., 2007, p. 23). This is considered to be one of three types of knowledge related to processes: process template knowledge, process instance knowledge and the mentioned process-related knowledge. It can include books, documents, experts, help files, manuals, laws and regulations and other sources that are usually referred to in order to execute the process correctly. Process-related knowledge can also be considered in terms of two types of knowledge: knowledge

about the process (process knowledge) and knowledge needed in the process

(functional knowledge) (Witschel et al., 2010).

Process-related knowledge can be used proactively to deliver knowledge at the

right time to the right users (Jung et al., 2007). Sharing process-related knowledge is

crucial to keep the established experience within the organization and maintain superior

performance regardless of employee instability (Witschel et al., 2010). This type of

knowledge is especially valuable to users that are new to the performance of these

processes. Knowledge about business processes is credited with better work

performance (Lee & Strong, 2004).

Knowledge Management in Organizations and Individual Learning

What is Knowledge?

Different perspectives associated with the definition of knowledge and how it is

transferred are found in Alavi and Leidner's (2001) multi-discipline review of knowledge

management literature. They discuss the different taxonomies of knowledge that

include the tacit-explicit classification of Polanyi (1962, 1967) and Nonaka (1994) and

the view of procedural (know-how), causal (know-why), conditional (know-when) and

relational (know-with) of Zack (1998) among other classifications. Understanding the

concept of knowledge and the related taxonomy is vital to the proper development of

theories and to the comprehension of the effect of organizational and IT-related

initiatives on knowledge management (Alavi & Leidner, 2001).

Where is Knowledge?

Knowledge cannot exist outside of an agent (Tuomi, 1999). Theories of situated organizational learning suggest that knowledge is embedded in practices, artifacts, symbols and relationships, in addition to existing in the minds of individuals (Nidumolu et al., 2001). Procedures and informal knowledge about how to complete processes are elicited from employees and codified into the program logic thus making the implicit knowledge part of the system (Zuboff, 1988). Knowledge is embedded into organizational routines via formalized structures that may seem restrictive but in reality support higher performance gains (Patnayakuni, Ruppel, & Rai, 2006). Therefore, business processes represent codified knowledge (Sutton, 2001). Other views of knowledge suggest that although knowledge can be represented through a variety of artifacts within an organization, people are the key agents of knowledge: "knowledge flows through technology, but resides in people" (Cannon, 1998, p. 16).

Within the realm of business processes, process-related knowledge lies in two separate systems; details about process-related knowledge such as process structure and resources are found in the BPMS and information regarding the technical aspects of automating the business process are embedded in the WFMS (Witschell et al., 2010).

How is Knowledge Transferred?

Several theories examine knowledge creation and transfer at individual and organizational levels. The dynamic theory of organizational knowledge creation presents the continuous dialogue between tacit and explicit knowledge that occurs within the four modes of knowledge creation: socialization, combination, externalization and internalization (Nonaka, 1994). The four modes are interdependent because they

each rely on and contribute to the other modes (Alavi & Leidner, 2001). Socialization occurs when new tacit knowledge is converted through interactions with others. The combination mode involves creating new explicit knowledge by combining existing explicit knowledge. The externalization and internalization modes involve both tacit and explicit knowledge and the creation of one based on the availability of the other. IT increases the exposure of the available knowledge across the organization, through the concept of scaffolding (Wood et al., 1976), so that knowledge creation is increased. IT is also credited for its role in the storage and transfer of knowledge along with the application of knowledge by embedding organizational routines in IT because knowledge cannot exist outside of an agent, as previously mentioned (Tuomi, 1999).

Ryu et al. (2005) investigate three different learning processes that potentially occur in a knowledge community: learning-by-investment, learning-by-doing, and learning-from-others and their impact on the organization. This study combines the learning-by-doing perspective with the learning-from-others where others is the software that scaffolds the learning process.

The just-in-time strategy of production industries and inventory management has been applied to training and learning for knowledge management purposes (Davenport & Glaser, 2002; Majchrzak, 2010). In CISCO, it was part of an enhanced e-learning vision that enabled the employees to access material when needed (Kelly & Bauer, 2003). Partners HealthCare embedded just-in-time knowledge into the daily technology tools to solve critical knowledge management issues (Davenport & Glaser, 2002). Davenport and Glaser (2002, p. 6) state that in the context of knowledge management "the key to success is to bake specialized knowledge into the jobs of highly skilled

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workers- to make the knowledge so readily accessible that it can't be avoided." That concept should also be considered for even the less-skilled workers that encounter business processes daily and rely on IT. Why not embed knowledge into their tools as well? There are benefits to be gained from a workforce that is knowledgeable in their business domain (Kock et al., 1997).

Impact of Automation on Organizational Knowledge

Generally, cases of work automation are considered to conform to the typical pattern of deskilling, which refers to stripping skilled jobs of their conceptual content specifically related to lower-level employees as the result of automation (Attewell & Rule, 1984; Zuboff, 1988). Based on the experience of manufacturing plants that transitioned from manual control to computer automated systems, it was observed that an inexperienced workforce could handle the job and where "managers complained that the computer system was becoming a crutch that prevented many operators from developing a superior knowledge of the process" (Zuboff, 1988, p. 68). Zuboff (1988) reports on a case of automation that affected banking employees' process knowledge negatively; "the computer system had become a black box into which a great deal of intelligence about banking procedures had been loaded. People at all levels had become dependent on that box and were poorly acquainted with much of the financial logic that was fundamental to the banking business" (Zuboff, 1988, p. 166).

However, innovation within organizations is seen as a necessity to handle the issue created by IT support of processes and automation since it has changed the relationship of task-related knowledge within organizations (Zuboff, 1988). Within some

organizations, the shift to automated process-oriented type of work led to a shift in responsibility as well. It was no longer expected that employees could provide the skill to complete a job but that they could assume responsibility for the successful operation of the process. This also includes the ability to control the process and make important decisions regarding the improvement of it (Zuboff, 1988).

Cognition

Cognitive processes play a key role in individual knowledge acquisition and retention. Cognition is considered to be a basis for understanding how humans process information and improve performance (Anderson, 2009). Terms such as perception, imagery, retention, recall, problem-solving and thinking among others refer to different aspects of cognition. Perception is defined to be "the process of interpreting and recognizing sensory information" (Ashcraft, 1998, p. 428) while cognition is defined as "the collection of mental processes and activities used in perceiving, learning, remembering, thinking and understanding and the act of using those processes" (Ashcraft, 1998, p.5). Therefore, cognition is considered to be a more comprehensive term since it includes post-perceptual processing of information (Baker, Burkman, & Jones, 2009). Classically, cognition was defined by Neisser (1967) as "all processes by which sensory input is transformed, reduced, elaborated, stored, recovered and used." Visual cognition specifically "deals with the processes by which a perceived, remembered and thought-about world is brought into being from as unpromising a beginning as the retinal patterns" (Neisser, 1967, p.4).

Learning from visual experience is evident in the experience of children and even animals. It is argued that some type of nonverbal storage medium must be available

because they cannot use words. Early empiricist philosophers such as Hobbes, Locke, Hume and Mill viewed memory as being related to how "one retains ideas or concepts which are nothing but slightly faded copies of sensory experiences" (Neisser, 1967 p.281). Information that is presented visually can be stored in different types of memory: iconic memory, which last for a couple of seconds at best, or verbal memory, which involves naming the figures we see (Anderson, 1990). "Everyday experience provides many proofs that visual information can outlast the stimulus almost indefinitely" (Neisser, 1967, p. 138). Humans' memory capacity is found to be much greater for information that has been presented visually rather than for information that was presented verbally (Anderson, 1990).

Visual perception is considered to be a constructive act because it is developed over a series of snapshots (Neisser, 1967). Each time an image is presented to a person new information is being added to a developing schematic model. That schematic model, however, is enhanced through two opposing operations: assimilation and accommodation (Russell, 1978). This means that when a person encounters new knowledge, he or she tries to assimilate it to knowledge that was gained previously. Also, individuals try to accommodate the new knowledge given the environmental variability and the need to change former criteria. "Intelligent behavior and understanding involve a two-way interaction between organism and environment controlled by assimilation and accommodation" (Russell, 1978, p. 93). Therefore, assimilation and accommodation are considered to move in opposite directions; assimilation is conservative while accommodation is considered to be more progressive (Russell, 1978).

The schemata is also relevant in the issue of recall because psychologists find that for recall to succeed a developed schemata must be present (Neisser, 1967). When information is considered important and relevant, a person tends to remember it for longer periods of time due to a mental schemata that is built for material we consider relevant as people tend to associate things when they learn them with things that they already know (Neisser, 1967).

Nevertheless, cognitive theories are not enough to predict human actions. These theories try to explain, but they are not considered to be mature enough to be able to predict in the presence of something stronger, which is personal motivations, which are difficult to suppress or control (Neisser, 1967).

Zone of Proximal Development and Scaffolding

Conceptualizing organizational employees as learners requires that we look at learning theories to support the learning process. I use Vygotsky's notion of the zone of proximal development (1978). ZPD is the difference between what a learner can do alone and what they can achieve if the learning process is guided appropriately. It is formally defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky, 1978, p 86). Learning as a process is considered to be more important than focusing on the learner's characteristics alone (Borthick et al., 2003). Social interaction, including formal instruction, is critical for the growth of human competence. This includes peer interaction as it sets up circumstances where the

learner perceives an internal need to reconcile different perspectives. Therefore, the realization that learning is both a cognitive and a social issue led to a call to resolve this dilemma through instructional design (Borthick et al., 2003).

Computers can be utilized in place of humans as a form of interaction with a learner (Saloman et al., 1989). Computers are able to provide models for information representation in the form of visualizations and offer support of difficult, tedious operations. Saloman et al. (1989) studied computers that provide reading-related guidance to students and the internalization of such guidance that lead to better reading performance. The ZPD notion has also been effective in designing systems for health promotion in the elderly (65+ years) (Lindgren & Nilsson, 2009).

Building on ZPD, the concept of using scaffolds in learning through hypermedia has been well-studied in traditional learning settings and curriculum development (Linn, 2000). Scaffolding is defined as being a "process that enables a child or novice to solve a problem, carry out a task or achieve a goal which would be beyond his unassisted efforts. This scaffolding consists of essentially of the adult controlling those elements of the task that are initially beyond the learner's capacity, thus permitting him to concentrate upon and complete only those elements that are within his range of competence" (Wood et al., 1976, p. 90). Scaffolding can be implemented in a variety of way including software-realized scaffolding (Jackson et al., 1996).

Learner-centered design (LCD) argues that learners are also users and need to be considered during the design of a system (Jackson et al., 1994). "Learners should have software available to them that represents information in a familiar way, but that also helps introduce them to more professional or symbolic representations" (Jackson et

al., 1994, p. 8). LCD claims that software should incorporate learning supports, scaffolds, to address learner needs (Soloway et al., 1996).

Two types of scaffolds have been identified: soft and hard scaffolds (Saye & Brush, 2002). Soft scaffolds are dynamic, situation-specific and offered on-the-fly. Hard scaffolds are static and planned ahead based on typical learner difficulties. Hard scaffolds can be embedded within multimedia such as in hyperlinks.

<p style="text-align:center">Visualization</p>

In this study, I employ visualization to act as a scaffold to aid in conveying process knowledge to users of an automated business process system. Visualization used to only mean the formation of mental visual images (Merriam-Webster) however currently it is considered to also refer to "a graphical representation of data or concepts" (Ware, 2000, p. 1). Data visualization is used to support effective decision making because it allows vast amounts of data to be interpreted in a quick manner. Data visualization also provides means to communicate information to others (Few, 2007). Making sense of large amounts of data has driven the need for better data visualization techniques and most of the developments have predominantly occurred in the last 30 years (Ware, 2000; Few, 2007).

Different tools and approaches have been developed along with related research regarding human perception and processing of these visual representations (Baker et al., 2009). Sensemaking, which is the ability to comprehend and be able to respond to a situation, is also impacted by data visualization (Baker et al., 2009.) Within MIS research, the Minnesota experiments are considered to be the earliest IS research

studies concerned with visual data representations (Dickson et al., 1977). They explored the relationship between system characteristics and decision outcomes based on how the information was displayed and in what form. Other studies have been concerned with the cognitive fit theory which explains that when the data presentation format matches the task type, cognitive fit is achieved and both decision making accuracy and speed are enhanced (Baker et al., 2009). More recently, business intelligence utilizes data visualization in the form of dashboards, displays that combine critical information on a single screen, to monitor business performance and respond effectively (Few, 2007). In relation to business processes, visualization provides the ability to perceive patterns linking different components (Ware, 2000).

Graphic objects represented on computer screens can serve as "a kind of extension for working memory, serving to hold information that can be used in cognitive operations" (Ware, 2000, p. 373.) Based on visualization related literature such as the cost of knowledge characteristic function (Card, Pirolli, & Mackinley, 1994), individuals can utilize well-designed data visualizations and rely on them better than their own memories. Ware (2000) states that the widest channel between human memory systems and computer-based memory systems is the "visual pathway from the computer into the human visual system" (p. 373). The information that flows from the screen and into the observer's iconic memory is considered to be up to tens of megabytes per second. Effective attention and pattern-finding mechanisms visually analyze the projected images.

In the area of problem solving, external representations of data are not only valuable for their ability to extend memory but also have influential benefits in the

cognitive skills of people (Zhang, 1997). Visualization that is dynamic, rather than static, has the potential to powerfully augment cognitive abilities (Ware, 2000). Furthermore, learning occurs when new links in memory are created (Hummel & Holyoak, 2001).

One of the characteristics of visualization is the degree to which it builds upon the knowledge already possessed by the viewer of the image. This enhances the impact of the visualized data. When a representation is consistent with a viewer's knowledge, it avoids imposing a higher cognitive cost (Hutchins 1986 and Kotovsky 1985).

Maps

Visualization can extend the cognition process while maps and diagrams can help organize the relationships for easier memory retrieval. This is considered an advantage of visualization through the use of maps where memory is being extended. It can also be considered as an extension of the cognitive process because the mind is freed up to take on different tasks (Ware, 2000). Furthermore, Chabris and Kosslyn (2005) note that "effective diagrams depict information the same way that our mental representation do." This is important because visual representations should highlight patterns in data and enable the viewer to derive meaning from the patterns.

In cases studied by Zuboff (1988), the ability of employees to visualize how different components of their manufacturing plant were working together helped them create a better understanding of how the process was completed. "The act of visualization brings internal resources to bear in order to soften the sense of distance, disconnection and uncertainty that is created by the withdrawal from a three-dimensional action context" (Zuboff, 1988, p. 87). This also aids in the creation of

mental images that supports understanding relationships and how processes are

executed (Zuboff, 1988.)

Finally, it is worth noting that long-term memory is created with the application of

meaning rather than the receiving of visual or verbal content only because: "the pattern,

once understood, could become part of a tacit store of knowledge" (Zuboff, 1988, p.

192). Therefore, understanding how a process works through the utilization of proper

visualization techniques aids also in creating long-term memory.

Research Model

In this section I present the theoretical model aimed at addressing the research

questions:

- o How does IT process support influence individual level process outcomes?

- o How does process visualization influence individual level process outcomes?

- o How do process characteristics (e.g. complexity) influence individual level

    process outcomes?

- o How do business process characteristics influence the relationship between

    IT process support, process visualization and process outcomes?

The research model suggests that IT process support, process visualization and

process complexity influence individual level process outcomes, including process

performance and process knowledge. The model also suggests that process complexity

moderates the relationship between IT process support, process visualization and

process outcomes. The proposed model is shown in Figure 1 below
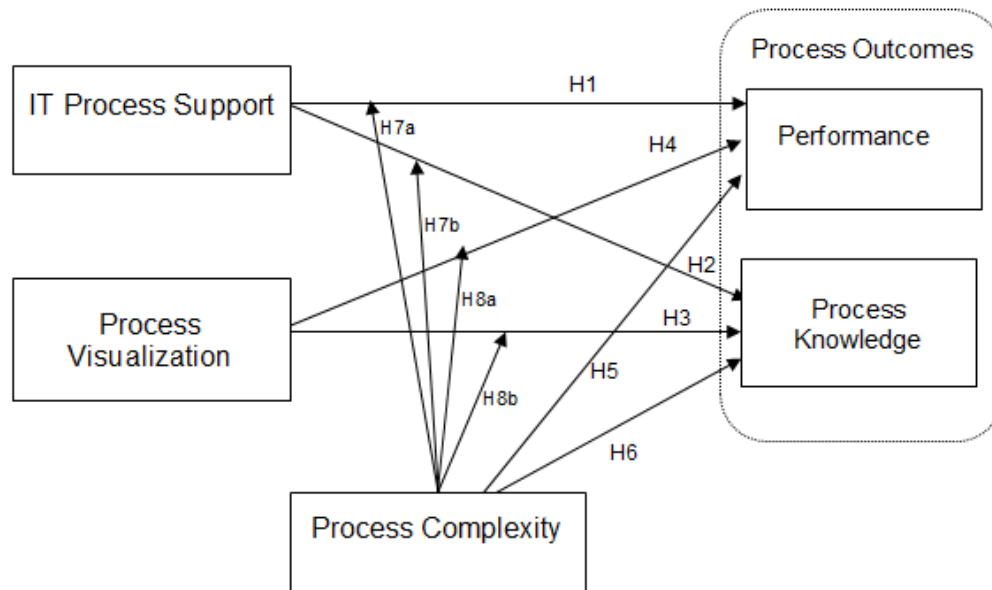
Figure 1. Research model.

The definitions of the key constructs are provided in Table 1.

Table 1

Construct Definitions

Construct	Definition
IT process support	The ability of information systems to guide users through business processes based on a set of rules that structure the flow of activities.
Process Visualization	The degree to which details of the process structure are made visible to the user through a graphical image such as a process map.
Process Complexity	The degree of difficulty associated with the variation of activities and control flow elements of a process.
Performance	Ability of the process participant to follow process steps and produce required process output in an efficient and effective manner. Defined in terms of time needed to complete a process and accuracy of the final result.
Process Knowledge	The degree to which the process participant has the knowledge (assimilated information) of activities, their flow and the rules associated with the business process.

IT Process Support and Process Outcomes

IT process support is employed to implement and enforce organizational routines as the user is guided through steps in the process by the system (Harmon, 2010; van der Aalst et al., 2003; Ouyang et al., 2010). IT process support is essential for effective organizational performance (Mutschler, 2008). Based on the automational effect of IT, as proposed by Mooney et al. (2001), I expect that task performance will be positively influenced by IT process support. At an individual level, time spent on completing a task will be less in the presence of IT process support because the user will not need to spend time consulting outside sources to ensure that business rules are followed. IT process support will also help reduce human error through rule enforcement and activity sequencing. Indeed, past research suggests that supported processes are completed more accurately by users with the enforcement of rules and sequencing of steps through the availability of IT process support as evidenced by the effect of process standardization efforts (Munstermann et al., 2010). Therefore, I propose the following:

Hypothesis1: IT process support is positively related to task performance (higher productivity and higher accuracy).

Although IT process support aids in increasing performance, it may have a different influence on gaining necessary process knowledge. Generally, cases of work automation are considered to conform to typical patterns of deskilling where automation is considered responsible for stripping skilled jobs of their conceptual content (Attewell & Rule, 1984; Zuboff, 1988). Users that rely on the system to guide them through the steps of a process may end up with limited explicit knowledge of the process structure because IT process support embeds that knowledge into the system.

In the presence of IT process support, users will be more likely to depend on the system without feeling the need to learn more about the process and rules. Users will be less interested in gaining new knowledge about the process because technology is enforcing the rules and doing the work for the user. Motivation is an important determinant of cognitive processes (Neisser, 1967). Consequently, lack of motivation is likely to negatively impact cognitive processes associated with the acquisition of process knowledge. Therefore, I propose the following:

Hypothesis 2: IT process support is negatively related to process knowledge.

Visualization and Process Outcomes

Although technology has traditionally been used for hiding process information from the user, the same technology can also be used for helping users acquire process knowledge by offering process visualization. Visualization refers to having process structure details explicitly presented to the IT user by the supporting IT system. In this study, the process will be made visible through the displaying of a process map.

Having the process visible is expected to influence user's process knowledge. When details about process structure are explicitly communicated to users, users are more likely to assimilate knowledge about the process because their cognition is engaged visually (Neisser, 1967; Ware, 2000). Graphic objects represented on computer screens can serve as "a kind of extension for working memory, serving to hold information that can be used in cognitive operations" (Ware, 2000, p. 373). Users will be more likely to remember details about the process such as rules and sequence of steps

when they see the process structure displayed in the form of a process map or another visual representation.

The visualization of the process structure helps the user to create a mental image of the process (Zuboff, 1988, Chabris & Kosslyn, 2005). This mental image is further enriched each time the user views the image of the process structure and additional details about the process structure are embedded in a user's long-term memory. Thus the process support system which also offers a visual representation of the process structure is likely to act like a tutor or coach to enhance a user's learning ability. Having the process structure visually displayed scaffolds the learning activity that is potentially taking place while the user is using the system (Vygotsky, 1978; Wood et al., 1976). Therefore, I propose:

Hypothesis 3: Process visualization is positively related to process knowledge. Having the process specifications (i.e. process structure) explicitly communicated to the user as part of the system may also influence task performance, yet in a negative way. Users may become occupied with the details of the displayed process which could encroach on the time otherwise spent to perform the task, thus negatively impacting productivity. More time may be needed to complete tasks because the user may become preoccupied with the displayed image. Also, a user's cognitive engagement with the display may impact their focus and accuracy levels may decrease accordingly. Therefore, I propose the following:

Hypothesis 4: Process visualization is negatively related to task performance.

The Effect of Process Complexity

Process features that add to the complexity of a process such as the number of steps in a process, the number of actors needed to complete a process and the branching found in the process structure are all dimensions of process complexity which add to the expected effort required to complete a process (Gribbins et al., 2006). Complexity of a process can also be increased through the number of decision points (control flow activities) found in a process (Frese, 1978). This will likely have an impact on task performance because multiple decision points increase the opportunities for errors to occur. This could arise from erroneous data entry of values needed for the decision points or in the absence of IT process support, errors in processing of those decision points. Therefore, I propose the following:

Hypothesis 5: Process complexity is negatively related to task performance.

The presence of higher complexity while negatively impacting task performance is expected to also have a negative impact on process knowledge. With more decision points or more actors as part of the process, knowledge regarding the details of the process may decrease. Increasing the process complexity of a business process increases the level of related details associated with the process which will likely negatively impact cognitive processes associated with the acquisition of process knowledge. Therefore, I propose the following:

Hypothesis 6: Process complexity is negatively related to process knowledge.

Process features that add to the complexity of a process are also expected to have a moderating effect on the proposed relationships related to IT process support and process visualization. Processes that are categorized at different levels of

complexity such as standard, routine or non-routine will most likely differ in terms of the impacts of IT process support and process visualization on process performance. We, therefore, propose the following:

Hypothesis 7: Process complexity has a moderating effect on the relationship between IT process support and process outcomes.

In the case of standard processes that are somewhat straightforward because they have pre-determined input and employ binary logic, IT process support should have a smaller impact on performance. Processes that are simple to complete may benefit less from being supported by IT, because there are fewer rules that govern the flow of activities and the decision logic. On the other hand, processes that are more complex will benefit more from being effectively supported by IT. Therefore:

H7a: The positive effect of IT process support on performance is stronger for more complex processes than for less complex processes.

Process complexity may have a different effect on the relationship between IT process support and process knowledge. In the case of the more simple standard processes, IT process support may have a less negative impact on process knowledge. Processes that are simpler and do not have much variety may be easier to follow by the user and hence, be easier to remember and describe. There is little complexity that is embedded into the technology so the user may have more knowledge about the process. However, for processes that are more complex, more knowledge is embedded into the technology and therefore I propose the following:

H7b: The negative effect of IT process support on process knowledge is stronger for more complex processes than for less complex processes.

The proposed impact of process visualization on individual process outcomes is also expected to be influenced by process complexity. In the case of standard processes, a process map is likely to carry relatively small amount of information, and therefore processing and assimilation are likely to happen relatively quickly and require little cognitive effort. On the other hand, visualization of a complex process is likely to result in a complex image. Cognitive processing of such image is likely to require significant cognitive resources. Therefore, I hypothesize:

Hypothesis 8: Process complexity has a moderating effect on the relationship between process visualization and process outcomes.

For processes that are high in complexity and include more detail, visual representation of the process is likely to be more distracting than a simpler process. Users may become occupied with trying to understand the process structure which may have an impact on their performance. Simpler process structures, however, may not be as engaging to the user and performance may not be impacted as severely. Therefore, I propose the following:

H8a: The negative effect of visualization on performance is stronger for more complex processes than for less complex processes.

The effect of process complexity on the relationship between process visualization and process knowledge may be further enhanced for more complex processes. Having a complex process visible to a user may enhance the knowledge gained because otherwise the details would be embedded in the technology. When the process structure is made visible to users, more knowledge can be gained about the many process details. However, the positive effect is probably greater for more complex

processes because simpler processes have less detail to display. Therefore, I propose

the following:

> H8b: The positive effect of visualization support on process knowledge is
>
> stronger for more complex processes than for less complex processes.

In summary, I build on the literature in the areas of business process

improvement, business process modeling, organizational knowledge creation and

individual learning, and propose a research model that relates individual level process

outcomes to the level of process complexity, IT process support and process

visualization.

CHAPTER 3

RESEARCH METHODOLOGY

This chapter describes the research methodology proposed to test the hypotheses presented in Chapter 2. The proposed experimental design, development of the research instrument and experimental procedure for both studies are detailed.

Pilot Studies

To ensure adequate design of the research study, a series of pilot studies were conducted. Each pilot study was conducted to evaluate a particular aspect of the research design, such as the experimental task, the experimental procedure, experimental manipulations and measurement instruments. The results of pilot studies were used to inform subsequent versions of the research design. Details of individual pilot studies are summarized in Table 2.

Table 2

Summary of Pilot Research Studies

Pilot study	Number of participants	Purpose
1	25	To assess instruction clarity regarding task procedure
2	54	To assess system response and proper randomization of treatments
3	41	To pilot Process knowledge questions

Research Study 1

The proposed model was tested empirically using an experimental simulation (McGrath, 1981) by manipulating three independent variables: IT process support, process visualization and process complexity. Two outcome variables, task performance and business process knowledge, were measured. Task performance was evaluated based on two dimensions: accuracy and productivity (Speier & Morris, 2003). Accuracy was measured based on the pre-existing outcomes of the process as per the assigned business rules. Productivity was assessed as the number of cases completed correctly within the allocated time. Business process knowledge was measured objectively along the dimensions of understanding and recall using a post task survey.

The study used a 2(process-support yes-no) x2(visualization yes-no) x2(complexity hi-low) between-subject design, producing a total of eight treatments. Subjects were randomly assigned to each treatment. The experimental design is represented in Figure 2 below.

IT process support (No)		Process Complexity	
		High (routine process)	Low (standard process)
Process Visualization	Yes	Performance Process Knowledge	Performance Process Knowledge
	No	Performance Process Knowledge	Performance Process Knowledge
IT process support (Yes)		Process Complexity	
		High (routine process)	Low (standard process)
Process Visualization	Yes	Performance Process Knowledge	Performance Process Knowledge
	No	Performance Process Knowledge	Performance Process Knowledge

Figure 2. Study 1 research design.

The participants of the experimental simulation were recruited from among undergraduate business majors enrolled in an undergraduate MIS course at a large southwestern US university. Incentives were provided in the form of extra credit (for participation) and the potential to win a $5 gift card (for being a top performer in a group). The incentive related to being a top-performer (monetary incentive) was to motivate the participants to try to do well in the task itself (i.e. to process as many customer requests correctly as possible). It was not related to how well they did on the process knowledge questions. Using monetary incentives for the top performers has previously been used in IS research to motivate subjects to perform well (Benbasat & Dexter, 1985).

Experimental Task

As a part of the experimental simulation, the subjects were asked to imagine that they were hired by a company providing food catering services and their job would involve processing requests for catering events based on a predefined business process (procedures and business rules). The event scheduling business process was selected as it is a typical business process that entry-level employees would most likely encounter when hired at an organization. As a part of their imaginary job, the participants were expected to handle customer event scheduling requests according to set business process rules.

The rules for event scheduling process were created for the purpose of this study after consultations with experts in the field of catering. Industry standards were used to maintain authenticity of the business process. This included the usual expected decision

points used when catering requests are processed. The process was then tested with various judges for clarity and consistency in relation to the business process procedures and rules. Different versions were created to operationalize high and low process complexity. Both versions were validated by experts in the field of catering.

The task involved processing customer catering requests based on customer request scenarios provided to them. An event calendar and approximately 20 customer requests were created in association with the business process. The subjects were asked to process as many requests as they can during the limited time period (five minutes was set). An example of a customer request scenario is provided below:

Customer # 1:

Request ID	Customer Name	Event date	Guest count	Event Location	Event Type	Staffing
1	Michelle Cody	August 17th	150	on-site	buffet-style	Staff requested

(This was a high complexity business process case)

As a part of event scheduling, the subjects were asked to use a Catering Order Entry system (COES)[1], which was developed for the purpose of the study.

Experimental Procedure

As a part of the recruitment effort, the prospective subjects were asked to follow a URL link to the study website, so they could use a computer of their choice to participate in the study. After accessing the study, the subjects were presented with the Informed Consent Notice. After agreeing to participate in the study by pressing the

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[1] The system was developed for the purpose of this study. The system was designed by the investigator and implemented by Russell Torres, doctoral student at the ITDS department, pro bono.

Agree button on the Informed Consent Notice, the subjects were asked to complete the experimental task and randomly assigned to one of eight treatment groups.

All subjects were provided with a short on-line training session related to the task including business process rules and instructions on how to use the Catering Order Entry system to complete the task. Depending on the treatment group to which they were assigned, the subjects used different versions of the Catering Order Entry system; therefore, the training focused on the version of the system that the subjects were assigned to. After training was completed, the subjects were asked to answer three questions about the process (pre-test questions). The correct answers to the test questions were then revealed to the subjects. The subjects were then redirected to the home screen of the Catering Order Entry system and were expected to complete the assigned task. Receiving training and completing the task took about 15 minutes. The system then re-directed the subjects to a survey that included process knowledge questions (part of the post-test), manipulation checks and demographic questions.

Manipulations and Experimental Treatments

For the purposes of this study, the independent variables were manipulated as follows:

IT process support was operationalized by different versions of the automated workflow system mock-up, COES (Catering Order Entry System). For conditions with no support, the system acted as an entry form only (no calculation was provided). Details regarding the different treatment descriptions will follow.

Process complexity was operationalized based on the categorization of standard or routine types of processes that represent differing complexity levels. One of the complexity dimensions was manipulated while the others were set constant for better control. The process represented in Figure 3a corresponds to the high complexity condition while Figure 3b represents the lower complexity condition. The low complexity process includes fewer gateways (decision points) and is characterized by a binary outcome (accept or reject case).
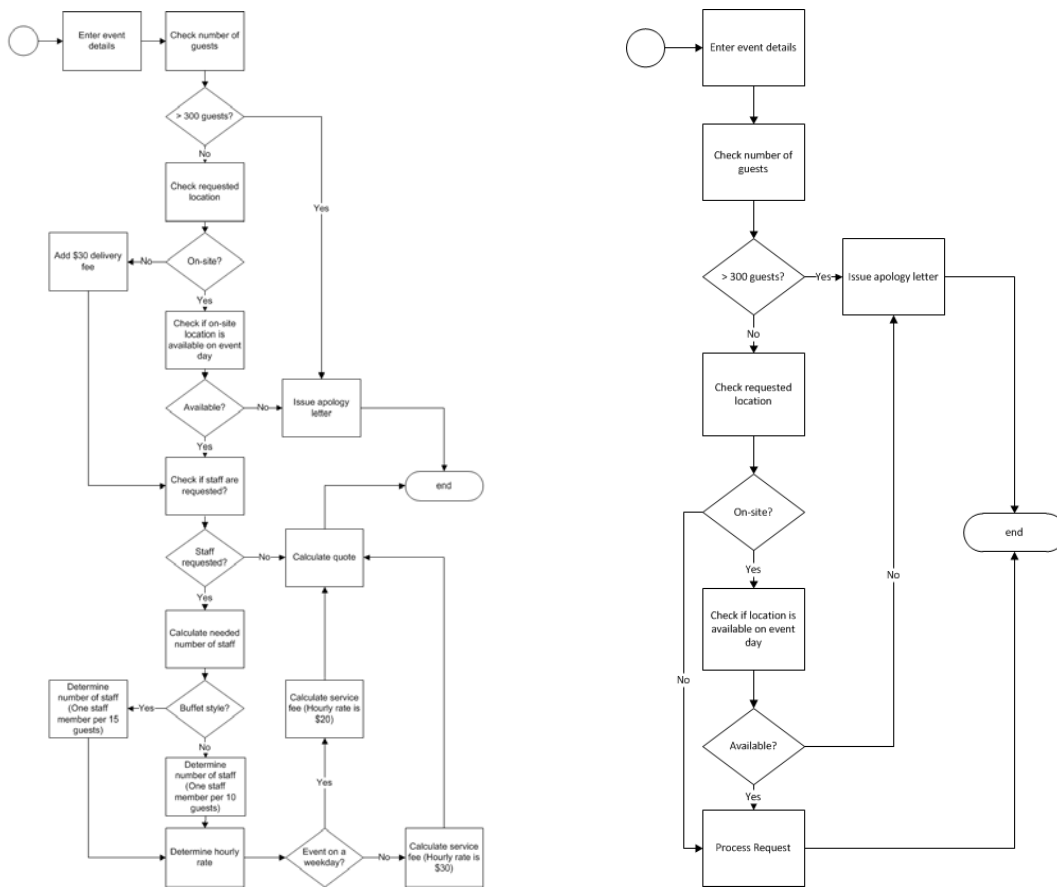

Figure 3. (a) High complexity process.   (b) Low complexity process.

Process visualization was operationalized by the display of an image of the process map to the user on the side of the screen for each customer entry screen.

The aforementioned manipulations were combined to produce the following eight treatment groups:

Treatment 1: High complexity- Manual processing – No visualization (i.e. no calculation support is offered by the system): Participants were asked to use the system to enter information regarding the customer request but were required to perform the necessary calculations manually using a calculator as per the business rules for the high complexity business process.

Treatment 2: High complexity- Manual processing – with visualization (i.e. no calculation support is offered by the system): Participants were asked to use the system to enter information regarding the customer request but were required to perform the necessary calculations manually using a calculator as per the business rules for the high complexity business process.. Subjects were presented with the image of a process map.

Treatment 3: High complexity- System supported processing – No visualization (i.e. full calculation support is offered by the system but no information regarding the process is displayed during processing): Participants were asked to use the system to enter information regarding the customer. Calculations were performed by the system as per the business rules for the high complexity business process and the calculation results were presented to the participants.

Treatment 4: High complexity- System supported processing – with visualization (i.e. full calculation support is offered by the system and the process map is displayed during processing): Participants were asked to use the system to enter information regarding the customer. Calculations were performed by the system as per the business

rules for the high complexity business process and the calculation results were presented to the participants. Subjects were presented with the image of a process map.

Treatment 5: Low complexity- Manual processing – No visualization (i.e. no decision support is offered by the system): Participants were asked to use the system to enter information regarding the customer request but were required process the requests manually with no decision support from the system as per the business rules for the low complexity business process.

Treatment 6: Low complexity- Manual processing – with visualization (i.e. no decision support is offered by the system): Participants were asked to use the system to enter information regarding the customer request but were required to process the requests manually with no decision support from the system as per the business rules for the low complexity business process.. Subjects were presented with the image of a process map.

Treatment 7: Low complexity- System supported processing – No visualization (i.e. decision support is offered by the system but no information regarding the process is displayed during processing): Participants were asked to use the system to enter information regarding the customer request. The system processed the requests as per the business rules for the low complexity business process and results were presented to the participants.

Treatment 8: Low complexity- System supported processing – with visualization (i.e. decision support is offered by the system and the process map is displayed during processing): Participants were asked to use the system to enter information regarding

the customer request. The system processed the requests as per the business rules for the low complexity business process and results were presented to the participants. Subjects were presented with the image of a process map.

Development of the survey instrument used for manipulation checks was completed via different stages. Items from existing scales were adapted to the context of the study and new items were created. Construct validity was assessed through several rounds of q-sorting (Moore & Benbasat, 1991; Petter, Straub, & Rai, 2007). If the measures identified by the researcher sufficiently match the q-sort results, construct validity is considered to have been achieved (Petter et al., 2007).

Items were printed on small strips of paper and were shuffled prior to presenting them to the different judges independently. Three rounds of q-sorting were completed with four different judges in each round. The judges included undergraduate students, graduate students (masters and doctoral) and a professor. Items were changed according to feedback from the participant/judge after each round was completed. During the first round, judges were asked to sort the items into several categories without having the construct labels provided (Moore & Benbasat, 1991). The judges were asked to provide their own labels for each construct category. Items that were found to be too confusing or had the lowest score were either changed or removed. The number of categories created by the first round of judges was consistent, therefore, the number of constructs were maintained.

During the second round, different judges were used and were provided with the construct labels as per the measurement development process (Moore & Benbasat, 1991). They were asked to place each item under the correct label. Convergent and

discriminant validity were confirmed when an item was consistently placed under the correct category. That indicated that the item had convergent validity with the other items in the construct category (under the same label) and discriminant validity with the items that were under different construct labels (Petter et al., 2007).

During the third and final round, the labels were removed again and the new judges were asked to group the items as they found sufficient and label them accordingly. Removing the labels during the q-sort session can help determine content validity, when the judge is required to define the category and assign a specific label (Petter et al., 2007). This is achieved through the assurance that all of the dimensions of the construct have been included.

<center>Process Knowledge Measures</center>

For the purpose of the study, process knowledge was measured objectively using a set of multiple choice questions. The questions were based on the underlying business rules of the event scheduling process. Some of the questions focused on the content of the business rules, such as under which circumstances an apology letter is issued to a customer. Other process knowledge questions focused on the flow of activities within the process, such as the sequence of checks performed as a part of scheduling request processing. Although participants in low and high complexity treatment groups were following different sets of business rules, the process knowledge questions were designed in such a way that they were applicable to both complexity conditions. However, the correct answers to the questions differed between the two levels of complexity.

A total of ten process knowledge questions were developed and pretested using data from pilot studies (see Appendix C). Three of these questions were selected to be part of the pre-test. This was done to evaluate the influence of training on the participants prior to completing the treatments. Seven of the questions were used as post-test process knowledge questions.

Research Study 2

Study 2 was designed to further investigate the effect of IT process support and process visualization under different experimental conditions. Particularly, the purpose of the study was to see if the results obtained in Study 1 would be different if participants receive minimal amount of process training prior to completing the task. The study was conducted for the high complexity condition, and only IT process support and process visualization were manipulated (see Figure 4).

Process Complexity (High)		Process Visualization	
		Yes	No
IT process support	Yes	Performance Process Knowledge	Performance Process Knowledge
	No	Performance Process Knowledge	Performance Process Knowledge

Figure 4. Study 2 research design.

Study 2 employed the same treatment manipulations for IT process support and process visualization as those described for Study 1, and used the high process complexity setting. The experimental procedure was the same as in Study 1, with the exception of the amount of process training received by the participant prior to completing the experimental task and the elimination of process knowledge pretest

(which may sensitize the participants to the need of retaining process knowledge and since they received no pre-task process training). Unlike in the experimental procedure in Study 1, training slides regarding the business process rules and procedures were not displayed to the participants before participation in the study. Instead, the participants only received training on how to use the system to complete the task. Thus, the participants received system training but not process training. However, the participants were encouraged to click on the available Business Rule and System Help links once they started using the system to learn more about the business process. Because the second study was limited to only high complexity condition (the condition in which IT process support and visualization were hypothesized to have a stronger effect), Study 2 is only used to test Hypotheses 1-4.

CHAPTER 4

DATA ANALYSIS

This chapter describes the data analysis and presents the results. The first section describes the data collection and details about the demographics of the participants along with hypothesis testing of Study 1. The second section presents the analysis and results of Study 2.

Study 1

A total of 162 subjects participated in the first study. However, only 150 completed all three parts of the study (training, system task, post-survey). Twenty responses were removed in cases where the respondent had completed the post-survey in an invalid fashion (same response for all questions) or did not complete the system task in a manner that showcased sufficient knowledge of the process (e.g. used random names instead of customer names in the catering request field). After these responses were removed from the data set, 130 total responses were retained for further analysis. Table 3 shows the breakdown of number of responses per treatment group. The table includes information regarding the total number of responses prior to data cleaning and the number of responses retained for data analysis. The number of retained respondents for each group meets the minimum practical guidelines that suggest sample size per group should be more than the number of dependent variables (Hair et al., 2010). Although, there are different sample sizes per treatment group, the size of the groups can be considered reasonably similar because (largest group/smallest group = 18/14=1.2) is acceptable (Pallant, 2010).

Table 3

Study 1 Response Breakdown per Treatment Group

Study 1	Total Completed	Total Used (after cleaning)
Treatment#1	18 responses	14 responses
Treatment#2	21 responses	18 responses
Treatment#3	19 responses	16 responses
Treatment#4	18 responses	15 responses
Treatment#5	20 responses	17 responses
Treatment#6	19 responses	17 responses
Treatment#7	18 responses	18 responses
Treatment#8	17 responses	15 responses
Total	150 responses	130 responses

Demographics

The majority of the study participants were male (63%) and were generally under the age of 31 years old with approximately half of the participants between the age of 22 and 31 and 39% between the age of 18 and 21. The majority of the study participants identified themselves as juniors (65.4%). Participant demographics are presented in Table 4 below. The participant demographics data are consistent with the makeup of students that are enrolled in the selected class where the study was conducted.

Table 4

Study 1 Response Demographics

Gender	Male	63.1%		Freshman	0%
	Female	36.9%		Sophomore	3.8%
Age	18-21	38.8%	Student Classification	Junior	65.4%
	22-31	49.6%		Senior	27.7%
	32-41	7.8%		Graduate	1.5%
	42-55	3.9%		Other	1.5%
	0ver 55	0%			

A Chi-square test of independence was performed to determine if a relationship exists between the demographic data and the occurrence in each treatment group. This was done to compare the observed proportion of cases (frequencies) of a specific gender, age group, or student classification and their occurrence in each treatment group (Pallant, 2012). The results in Table 5 indicate that there was no association between the respondents' gender, age, or student classification and their random assignment to one of the eight treatment groups.

Table 5

Chi-square Analysis of Study 1 Responses

Study 1	Chi-square statistic	p-value
Age	16.135	.762
Gender	9.047	.249
Student Classification	31.976	.275

Factor Analysis and Reliability Measures

The psychometric properties of the measurement instruments used for manipulation checks, i.e. to measure perceived complexity and perceived system support were assessed using exploratory factor analysis and reliability measures. Exploratory factor analysis was conducted to assess construct validity of these items (Kerlinger & Lee, 2000). A total of 13 items were hypothesized to load on the three following factors based on the output of the q-sort previously conducted: perceived system usefulness (4 items), perceived system ease of use (4 items), and perceived complexity (5 items).

Principal component analysis using a varimax rotation with eigenvalues greater than 1 was used to extract the factors. Items with a factor loading that was less than 0.5 were suppressed. The initial exploratory factor analysis of the items is shown in Table 6.

Table 6

Initial Exploratory Factor Analysis

Item	Component	
	1	2
PercComplexity1	.535	
PercComplexity2		.892
PercComplexity3R		.703
PercComplexity4		.878
PercComplexity5		.904
PEU1	.832	
PEU2	-.567	.585
PEU3		.769
PEU4	.632	
PU1	.835	
PU2	.874	
PU3	.841	
PU4	.890	

Cross loadings were removed and the analysis was repeated for several rounds until sufficient loading on one factor was achieved. The final iteration of the factor analysis is found in Table 7.

Table 7

Final Exploratory Factor Analysis

Item	Component	
	1	2
PercComplexity2		.911
PercComplexity3R		.738
PercComplexity4		.873
PercComplexity5		.901
PEU1	.834	
PEU4	.643	
PU1	.839	
PU2	.883	
PU3	.858	
PU4	.893	

The factor analysis revealed that the items that were expected to measure perceived system ease of use (PEU) were significantly loading on the perceived system usefulness (PU) factor (with loadings greater than 0.6). This indicates that the items were perceived by the respondents to measure system characteristics but could not be separated from each other. I combined the items under the related construct perceived system usefulness which was used as a manipulation check.

Cronbach's alpha was then used to examine the internal consistency for each factor (Huck, 2008). Values greater than 0.7 are considered acceptable Cronbach's alpha values (Hair et al., 2006). All factors achieved Cronbach's alpha of 0.9 and above which indicates high internal reliability of the factors used in the survey.

Table 8

Cronbach's Alpha Values

Factor	Cronbach's alpha
Perceived System Usefulness	.925
Perceived Complexity	.908

Manipulation Checks

      A manipulation check for perceived complexity was conducted following the system task to ensure that the two complexity treatment levels were perceived as different to the users. The results revealed that the participants did perceive a difference in complexity based on their treatment groups ($F(1,128) = 6.370$, $p = .013$).

      A manipulation check for perceived system usefulness was also conducted following the treatments to confirm that the IT process support offered by the system was perceived as being useful (compared to no IT support in the manual treatments). The results revealed that the participants did perceive a difference in system usefulness in the presence of IT support based on their treatment groups ($F(1,126) = 12.95$, $p < .000$).

Hypothesis Testing and Results

      In order to test the study's hypothesized relationships between the IT configurations (support and visualization) and the process outcomes (task performance and process knowledge), two separate between-groups analysis of variance (ANOVA) were conducted instead of a one-way between-group multivariate analysis of variance

(MANOVA). This was due to the low correlation between the two dependent variables: task performance and process knowledge $r = .030$, $p = .737$ (Pallant, 2010).

Assumption Validation

The data were examined for outliers by analyzing the related boxplot diagrams. Two points were identified in the process knowledge data set that had values of 0. They were from treatments #3 and #5. The data points were retained given a score of 0 is an expected value in this data set meaning that the participant did not answer any of the process knowledge questions correctly. Furthermore, I examined the 5% trimmed mean and compared it to the mean. They were found to be very close in range, indicating that the outliers were not extremely influential on the data (Pallant, 2010).

Next, I examined the data for normality along with skewness and kurtosis, which are measures of the deviation from normality. Skewness and kurtosis values approximating zero reflect a normal distribution (Byrne, 1998). Values that are larger than 3 for skewness and 7 for kurtosis reflect moderate to severe deviations from normality (Byrne, 1998). The resulting values of the analyzed data reveal that the skewness and kurtosis values are within the acceptable range.

Normality of the dependent variables task performance and process knowledge were further investigated. Although the associated statistical tests (e.g. Kolmogorov-Smirnoff) were found to be statistically significant, meaning that both data sets deviated from normality, I assessed the probability plots (Q-Q plots) along with the distribution of the studentized residuals using histograms (Pallant, 2010). The probability plots and

studentized residual histograms revealed that both distributions approximated the normal curve with a somewhat unimodal shape.

To further account for the potential non-normality of the data sets, I transformed the variables. Transformation involves mathematically modifying the data points using a suitable formula to achieve a distribution that looks more normal (Pallant, 2010). For task performance, I used the logarithm function to transform it because it was positively skewed (skewness = 0.468) (Pallant, 2010). For process knowledge, I used both the reflect and logarithm functions because it was negatively skewed (skewness = -0.994) (Pallant, 2010). The resulting residual plots revealed that a normal distribution was achieved through the transformation. The transformed data sets were retained to confirm the significance of the resulting models. However, I continued to use the original data sets in the analysis for interpretation clarity because the preliminary analysis of the plots did not entirely violate the normality assumption.

Task Performance

The first ANOVA model was run to assess the impact of IT configurations and process complexity on task performance. The independent variables were the presence of IT process support (system supported processing vs. manual processing), visualization condition (displayed vs. not) and type of process complexity (high complexity vs. low complexity). The dependent variable was task performance (number of accurately completed cases). I checked for homogeneity of variance to test whether the variance in performance was not significantly different for each of the treatment groups (Pallant, 2010). I conducted Levene's test for homogeneity of variance and the

significance of that result revealed that there may be a violation of this assumption. However, analysis of variance may be robust to this violation if the group sizes are similar which is the case for this study. The difference between the largest group (18 respondents) and the smallest group (14) is (18/14 = 1.28) meaning that there is not a significant difference in group sizes (Pallant, 2010). Furthermore, in light of this assumption violation, I will assess the significance of the ANOVA test for task performance at a more stringent alpha level as recommended by Pallant (2010).

The results of the ANOVA indicated that there was a statistically significant interaction effect between IT support and complexity ($F(1,121) = 4.5$, $p = .035$) with a small effect size (partial eta squared = .036). Effect size was determined in relation to partial eta squared because it indicates the proportion of variance of the dependent variable that is explained by the independent variable (Pallant, 2010). Therefore, approximately 3.6% of the variance in task performance scores was explained by the interaction of IT support and complexity. Furthermore, there were significant main effects on task performance caused by IT process support and complexity ($F(1,121) = 28.5$, $p < .000$; $F(1,121) = 69.6$, $p < .000$) respectively with large effect sizes (19% of the variance was explained by IT support while 36.5% was explained by complexity). However, there was not a significant main effect for visualization ($F(1,121) = .089$, $p = .766$). There were also no significant interaction effects (neither 2-way nor 3-way) between visualization and support and complexity ($F(1,121) = .004$, $p = .952$; $F(1,121) = .141$, $p = .708$; $F(1,121) = .226$, $p = .635$). This indicates that visualization had no impact on task performance which indicates no support for H4.

Table 9

ANOVA Results for Task Performance in Study 1

Tests of Between-Subjects Effects						
Dependent Variable: Performance						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	591.556[a]	7	84.508	14.763	.000	.461
Intercept	3757.261	1	3757.261	656.365	.000	.844
Complexity	398.747	1	398.747	69.658	.000	.365
Support	163.191	1	163.191	28.508	.000	.191
Visualization	.510	1	.510	.089	.766	.001
complexity * support	26.020	1	26.020	4.545	.035	.036
complexity * visualization	.809	1	.809	.141	.708	.001
support * visualization	.020	1	.020	.004	.952	.000
complexity * support * visualization	1.293	1	1.293	.226	.635	.002
Error	692.646	121	5.724			
Total	5159.000	129				
Corrected Total	1284.202	128				
a. R Squared = .461 (Adjusted R Squared = .429)						

The results of the analysis indicated that participants in the low complexity treatment condition achieved higher performance scores ($M = 7.179$) than did the participants in the high complexity treatment condition ($M = 3.64$). This indicates that complexity did indeed impact performance negatively and supports the hypothesized relationship (H5). Furthermore, for the participants in the IT supported process treatment condition, performance scores were higher ($M = 6.59$) than for the participants in the non-supported treatment condition ($M = 4.38$). This indicates that IT process support impacts task performance positively as hypothesized in H1. Parameter estimates of the tested model are found in Table 10.

Table 10

Parameter Estimates for Task Performance in Study 1

Parameter Estimates						
Dependent Variable: Performance						
Parameter	B	Std.	t	Sig.	95% Confidence Interval	
		Error			Lower Bound	Upper Bound
Intercept	5.226	.424	12.337	.000	4.387	6.064
[complexity=0]	2.653	.590	4.497	.000	1.485	3.820
[complexity=1]	0^a	.	.	.	.	.
[support=0]	-3.161	.599	-5.277	.000	-4.347	-1.976
[support=1]	0^a	.	.	.	.	.
[complexity=0] * [support=0]	1.783	.831	2.144	.034	.137	3.428
[complexity=0] * [support=1]	0^a	.	.	.	.	.
[complexity=1] * [support=0]	0^a	.	.	.	.	.
[complexity=1] * [support=1]	0^a	.	.	.	.	.
a. This parameter is set to zero because it is redundant.						

Figure 5 displays the interaction between IT process support and complexity and lends support to H7a where the positive effect of IT process support on task performance would be stronger for the more complex process than for the less complex ones.
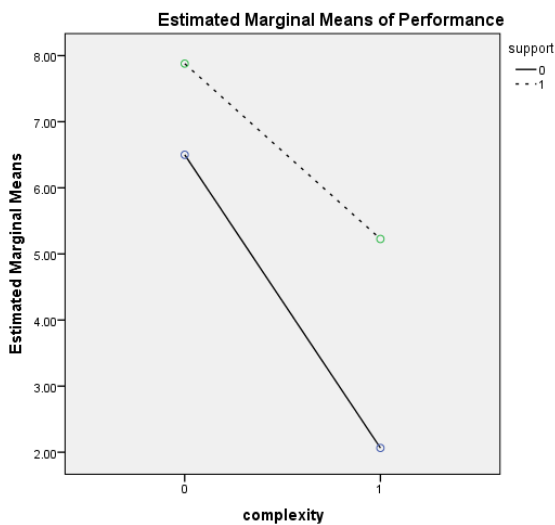

Figure 5 Interaction of complexity and support for task performance in Study 1.

Process Knowledge

The analysis of the second model was conducted as an analysis of covariance (ANCOVA) and was run to assess the impact of IT configurations and process complexity on process knowledge. The independent variables were the presence of IT process support (system supported processing vs. manual processing), visualization condition (displayed vs. not) and type of process complexity (high complexity vs. low complexity). The dependent variable was process knowledge (scores on questions related to the process administered following completion of the task). Task performance was treated as a covariate because I was interested in exploring the differences in process knowledge while statistically controlling for the effects of task performance. This was important due to the variation in complexity that would have an effect on performance and related knowledge. I was interested in isolating those differences from the effects of the actual treatments to study process knowledge.

I conducted Levene's test for homogeneity of variance and the results confirmed that I had not violated the assumption of homogeneity of variance because the results were not significant ($p = .103 > .05$). In assessing the use of performance a covariate, I conducted a test of homogeneity of regression slopes that is concerned with the relationship between the dependent variables and the covariate. It assesses whether the relationship between the covariate (performance) and the dependent variable (process knowledge) is the same in each of the groups. This was confirmed by evaluating the interaction terms between the treatment groups defined by (support and complexity) and task performance ($F(1,123) = .641$, $p = .425$ and $F(1,123) = .193$, $p = .425$ respectively).

The results of the ANCOVA revealed that after adjusting for task performance, the main effects were statistically significant for the following factors: support: $F(1,120) = 5.9$, $p = .017$; complexity: $F(1,120) = 10.9$, $p = .001$ with small (.047) and medium (.084) effect sizes respectively. However, the interaction of these two factors was not found to be significant ($F(1,120) = .581$, $p = .447$). Visualization was not a significant factor in relation to process knowledge nor was it significant in any interaction with the other factors ($F(1,120) = .012$, $p = .912$).

Table 11

ANOVA Results for Process Knowledge in Study 1

Tests of Between-Subjects Effects						
Dependent Variable: ProcKnowledge						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	29.530[a]	8	3.691	1.891	.068	.112
Intercept	285.510	1	285.510	146.238	.000	.549
Performance	14.311	1	14.311	7.330	.008	.058
complexity	21.443	1	21.443	10.983	.001	.084
support	11.524	1	11.524	5.902	.017	.047
visualization	.024	1	.024	.012	.912	.000
complexity * support	1.135	1	1.135	.581	.447	.005
complexity * visualization	1.900	1	1.900	.973	.326	.008
support * visualization	.087	1	.087	.045	.833	.000
complexity * support * visualization	.413	1	.413	.212	.646	.002
Error	234.284	120	1.952			
Total	2944.000	129				
Corrected Total	263.814	128				
a. R Squared = .112 (Adjusted R Squared = .053)						

The results of the analysis indicated that participants in the low complexity treatment condition achieved lower process knowledge scores ($M = 4.31$) than did the

participants in the high complexity treatment condition (M = 4.82). This contradicts

hypothesis H6 where it was expected that the higher the complexity, the less knowledge

will be gained. Furthermore, for the participants in the IT supported process treatment

condition, process knowledge scores were lower (M = 4.3) than for the participants in

the non-supported treatment condition (M = 4.7). This supports H2. Parameter

estimates of the tested model are found in Table 12.

Table 12

Parameter Estimates for Process Knowledge in Study 1

Parameter Estimates						
Dependent Variable: ProcessKnowledge						
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	3.847	.370	10.412	.000	3.116	4.579
Performance	.147	.052	2.796	.006	.043	.250
[complexity=0]	-.820	.372	-2.201	.030	-1.557	-.083
[complexity=1]	0[a]	.	.	.	.	.
[support=0]	.883	.388	2.274	.025	.114	1.651
[support=1]	0[a]	.	.	.	.	.
[complexity=0] * [support=0]	-.421	.496	-.849	.397	-1.403	.560
[complexity=0] * [support=1]	0[a]	.	.	.	.	.
[complexity=1] * [support=0]	0[a]	.	.	.	.	.
[complexity=1] * [support=1]	0[a]	.	.	.	.	.
a. This parameter is set to zero because it is redundant.						

Results of hypotheses testing in Study 1 are summarized in Table 13.

Table 13

Summary of Hypotheses Testing in Study 1

Hypothesis	P-value	Conclusion
H1: IT Process support is positively related to task performance (higher productivity and higher accuracy).	.000	Supported
H2: IT Process support is negatively related to process knowledge.	.017	Supported
H3: Process visualization is positively related to process knowledge.	.912	Not supported
H4: Process visualization is negatively related to task performance.	.766	Not supported
H5: Process complexity is negatively related to task performance	.000	Supported
H6: Process complexity is negatively related to process knowledge	.001	Contradicted
H7a: The positive effect of IT process support on performance is stronger for more complex processes than for less complex processes.	.035	Supported
H7b: The negative effect of IT process support on process knowledge is stronger for more complex processes than for less complex processes.	.447	Not supported
H8a: The negative effect of visualization on performance is stronger for more complex processes than for less complex processes.	.708	Not supported
H8b: The positive effect of visualization on process knowledge is stronger for more complex processes than for less complex processes.	.326	Not supported

**p<0.05
***p<0.001
- - - - ▸ Hypothesis not supported
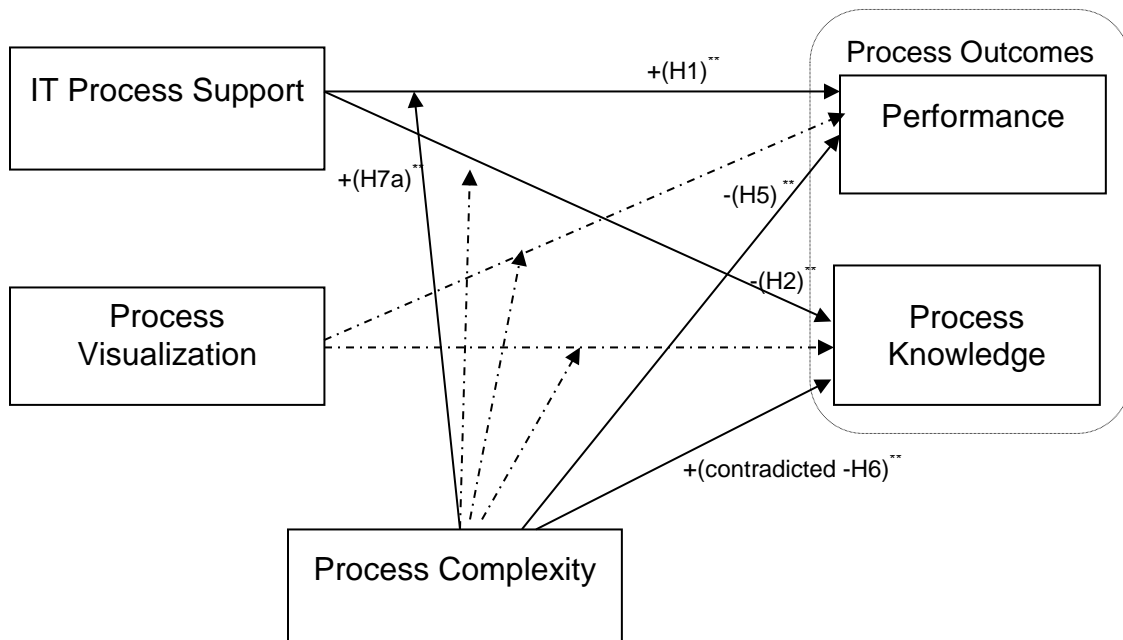
Figure 6. Results of hypotheses testing in Study 1.

Study 2

To further test the study's hypotheses, I ran the study using different training approaches as presented in Chapter 3 under Design Modifications. Detailed training regarding the business process was removed and left up to the study subject to seek out the information in case they needed it.

The study was completed by 50 participants. Table 14 displays the breakdown of number of responses per treatment group. Although, the number of respondents per cell is lower than recommended, this study is being used as a preliminary investigation into effects of training.

Table 14

Study 2 Response Breakdown per Treatment Group

Study 2	Total Completed
Treatment#1	13 responses
Treatment#2	11 responses
Treatment#3	11 responses
Treatment#4	15 responses
Total	50 responses

Demographics

Demographics of the participants in Study 2 were fairly similar to the participants in Study 1, where 55% of the respondents were male and the majority was under the age of 31 years old (96%). Most of the study participants identified themselves as seniors (54%) followed by juniors (44%).

Table 15

Study 2 Response Demographics

Gender	Male	55%	Student Classification	Freshman	0%
	Female	45%		Sophomore	0%
Age	18-21	42%		Junior	44%
	22-31	54%		Senior	54%
	32-41	2%		Graduate	0%
	42-55	2%		Other	2%
	Over 55	0%			

A Chi-square test of independence was performed to determine if a relationship exists between the demographic data and the occurrence in each treatment group. The results indicate that there was no association between the respondents' gender, age, or student classification and their random assignment to one of the four treatment groups.

Table 16

Chi-square Analysis of Study 2 Responses

Study 2	Chi-square statistic	p-value
Age	12.332	.195
Gender	.901	.825
Student Classification	4.409	.621

Hypothesis Testing and Results

To test the hypothesized relationships in Study 2 between the IT configurations (support and visualization) and the process outcomes (task performance and process knowledge), I conducted two separate between-groups analysis of variance (ANOVA)

instead of a one-way between-group multivariate analysis of variance (MANOVA). This was due to the low correlation between the two dependent variables: task performance and process knowledge $r = .266$, $p = .062$ (Pallant, 2010).

Assumption Validation

The data were examined for outliers by analyzing the related boxplot diagrams. One point was identified in the performance data set that had a higher value than the rest of the data set. It was from treatment #4 and was retained because such high performance is expected when the system offers IT support. Furthermore, the comparing of the 5% trimmed mean and mean revealed that both values were within the same range which indicates that the outlier was not extremely influential.

I then examined the data for normality along with skewness and kurtosis which were found to be within the acceptable ranges. Assessment of the probability plots (Q-Q plots) along with the distribution of the studentized residuals using histograms revealed that both the distributions of performance and process knowledge approximated the normal curve.

Task Performance

I first ran an ANOVA model to re-assess the impact of IT configurations on task performance. Because complexity was not being manipulated in this study, the independent variables were the presence of IT process support (system supported processing vs. manual processing) and visualization (displayed vs. not). The dependent variable was task performance (number of accurately completed cases). I conducted

Levene's test for the assumption of homogeneity of variance and the significance of that result revealed that there may be a violation of this assumption ($p < .005$). Therefore, in light of this assumption violation, I assessed the significance of the ANOVA test at a more stringent alpha level as recommended by Pallant (2010).

The results of the ANOVA reconfirmed the significant main effect of IT support on task performance ($F(1,46) = 21.86$, $p < .000$) with a large effect size (32.2%). However, there was still not a significant main effect for visualization ($F(1,46) = .084$, $p = .773$) nor was there a significant interaction effect between visualization and support ($F(1,46) = 1.138$, $p = .292$;). This further supports that visualization had no impact on task performance which indicates no support for H4. ANOVA results are found in Table 17 and parameter estimates of the tested model are found in Table 18.

Table 17

ANOVA Results for Task Performance in Study 2

Tests of Between-Subjects Effects						
Dependent Variable: Performance						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	81.172[a]	3	27.057	7.812	.000	.338
Intercept	287.826	1	287.826	83.099	.000	.644
Support	75.742	1	75.742	21.868	.000	.322
Visualization	.292	1	.292	.084	.773	.002
Support * Visualization	3.941	1	3.941	1.138	.292	.024
Error	159.328	46	3.464			
Total	553.000	50				
Corrected Total	240.500	49				
a. R Squared = .338 (Adjusted R Squared = .294)						

Table 18

Parameter Estimates for Task Performance in Study 2

Parameter Estimates						
Dependent Variable: Performance						
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	3.867	.481	8.047	.000	2.899	4.834
[Support=0]	-3.048	.739	-4.126	.000	-4.536	-1.561
[Support=1]	0^a	.	.	.	.	.
[Visualization=0]	-.412	.739	-.558	.580	-1.899	1.075
[Visualization=1]	0^a	.	.	.	.	.
[Support=0] * [Visualization=0]	1.132	1.062	1.067	.292	-1.005	3.269
[Support=0] * [Visualization=1]	0^a	.	.	.	.	.
[Support=1] * [Visualization=0]	0^a	.	.	.	.	.
[Support=1] * [Visualization=1]	0^a	.	.	.	.	.
a. This parameter is set to zero because it is redundant.						

Process Knowledge

I then reassessed the impact of IT configurations on process knowledge where

the independent variables were the presence of IT process support (system supported

processing vs. manual processing) and visualization (displayed vs. not). The dependent

variable was process knowledge (scores on questions related to the process

administered following completion of the task). I conducted Levene's test for

homogeneity of variance and the results confirmed that I had not violated the

assumption of homogeneity of variance because the finding of the test were not

significant ($p = .315 > .05$).

The results of the ANOVA revealed that the main effect of support was still statistically significant in this new training approach: $F(1,46) = 11.693, p = .001$. This supported the findings of the Study 1. However, under this new training approach, the effect of visualization was moderately significant ($F(1,46) = 2.96$, $p = .092$) with a medium effect size (6%). This offers support to the hypothesized relationship (H3) that visualization of the process map positively impacts process knowledge.

Table 19

ANOVA Results for Process Knowledge in Study 2

Tests of Between-Subjects Effects						
Dependent Variable: ProcKnowledge						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20.929[a]	3	6.976	4.540	.007	.228
Intercept	694.796	1	694.796	452.118	.000	.908
Support	17.970	1	17.970	11.693	.001	.203
Visualization	4.560	1	4.560	2.967	.092	.061
Support * Visualization	.172	1	.172	.112	.740	.002
Error	70.691	46	1.537			
Total	791.000	50				
Corrected Total	91.620	49				
a. R Squared = .228 (Adjusted R Squared = .178)						

The results therefore lend support that for participants in the IT supported process treatment condition, process knowledge scores were lower ($M = 3.19$) than for the participants in the non-supported treatment condition ($M = 4.33$). This shows further support for H2. The results of Study 2 furthermore show that process knowledge scores were higher for the participants in the treatments that included visual displays of the process ($M = 3.96$) than for the participants that were not shown process maps ($M =$

3.50). This offers support for H3 at an alpha level of 0.1. Parameter estimates of the

tested model are found in Table 20.

Table 20

Parameter Estimates for Process Knowledge in Study 2

Parameter Estimates						
Dependent Variable: ProcKnowledge						
Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Intercept	3.448	.283	12.198	.000	2.880	4.017
[Support=0]	1.213	.350	3.465	.001	.509	1.917
[Support=1]	0[a]	.	.	.	.	.
[Visualization=0]	-.605	.350	-1.729	.090	-1.310	.099
[Visualization=1]	0[a]	.	.	.	.	.
a. This parameter is set to zero because it is redundant.						

Results of hypotheses testing in Study 2 are summarized in Table 21. Note that

these results were obtained under high process complexity condition.

Table 21

Summary of Hypotheses Testing in Study 2

Hypothesis	P-value	Conclusion
H1: IT Process support is positively related to task performance (higher productivity and higher accuracy).	.000	Supported
H2: IT Process support is negatively related to process knowledge.	.001	Supported
H3: Process visualization is positively related to process knowledge.	.091	Supported (alpha=0.1)
H4: Process visualization is negatively related to task performance.	.773	Not supported
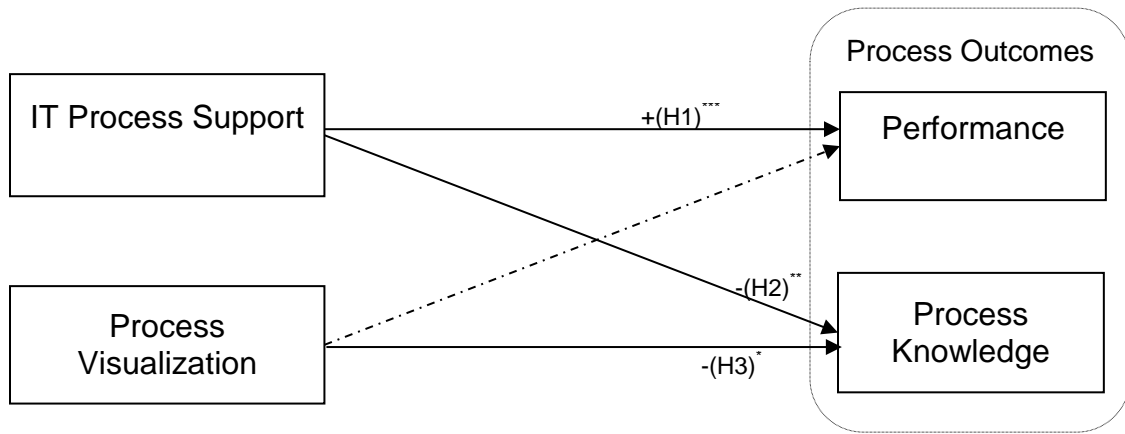
Process complexity _ High

*p<0.1
**p<0.05
***p<0.001
– · – · –► Hypothesis not supported

Figure 7. Results of partial hypotheses testing in Study 2.

CHAPTER 5

DISCUSSION

This dissertation explores the relationship between information technology (IT)

process support, process visualization, process complexity and individual level process

outcomes (task performance and process knowledge). This chapter presents a

discussion of the findings along with identification of the study limitations, contributions

to both research and practice and future research directions.

Discussion of Findings

Business process management (BPM) has been considered important to

organizations because it can offer lower costs, higher performance and increased

quality (Hammer, 2010). IT has played a significant role in extending those benefits

through the automation of business processes as part of Workflow Management

Systems and by offering process support. Although the benefits of process automation

from the organizational view-point have been extensively researched (Venkatesh,

2006), investigation regarding the effect of such IT process support at the individual

level has been limited.

Grounded in the business process management, organizational knowledge

creation and visualization literature, the theoretical model proposed here was developed

to relate the level of process support by IT and the level of visualization to individual

level process outcomes at different levels of process complexity. The model was tested

using two experimental studies. The results of the two studies provide support for most

of the relationships hypothesized in the research model. Detailed discussion of study

results as related to specific relationships hypothesized in the research model is

presented below.

The Effect of IT Process Support, Visualization and Complexity on Task

Performance

Performance was one of the process outcomes that were important in this study.

The improvement of task productivity for individuals in terms of time and quality are a

central theme of IT impact on individual level process outcomes (Torkzadeh & Doll,

1999). Furthermore, individual productivity is considered one of the individual-level

impacts of IS success (Gable et al., 2008). It includes improved executive efficiency and

task performance. In this study, task performance was defined in relation to an

individual's ability to follow process steps and produce required process outputs in an

efficient and effective manner. For the purposes of this study, it was operationalized

with measures of productivity (number of completed cases) and accuracy.

IT Process Support and Task Performance:

It was posited in this study that task performance may be positively enhanced

through IT process support by applying both rule and control-flow support (H1). IT

process support has been defined in this study as the information system's ability to

guide users through business processes based on a set of rules that structure the flow

of activities. It aims to implement and enforce organizational routines as the user is

guided through the process steps in the system (Harmon, 2010; van der Aalst et al.,

2003; Ouyang et al., 2010). It was operationalized in this study through the use of a

mock information system that would handle business process activities by enforcing the process rules and flow. For the non-process supported scenarios, the system merely acted like an online form for collecting information. No processing or rule-enforcing took place.

The results of both studies provide support for Hypothesis 1, suggesting that process support is critical for enhancing user performance. This is in line with the automational effects of IT as proposed by Mooney et al. (2001). Furthermore, past research has discussed that when processes are supported by IT, they are completed more accurately because business rules and sequencing of steps are enforced through IT (Munstermann et al., 2010).

Process Visualization and Task Performance

IT has also been credited with the ability to engage a user's cognition by providing models for information representation in the form of visualizations as well as offering support for tedious operations (Saloman et al., 1989). In this study, the visualization of the business process map was incorporated in the form of process visualization, which was defined as the degree to which details of the process structure was made visible to the user through a graphical image. This was operationalized in this study through the display of the process map.

Process visualization was posited to negatively impact task performance (H4). The results of both studies, however, indicated that task performance was not impacted by process visualization as expected. This could be related to the participants being more concerned and motivated to complete the task and were not as easily distracted

by the displayed image of the process map. Alternatively, the expected negative impact

may have been countered by how the image was displayed to the side of the screen

and was considered as a visual aid and not the central element on the screen. This non-

significant result should be considered a favorable outcome because it indicates that

visualization has no negative impact on performance.

Process Complexity and Task Performance

Process features that add to the complexity of a process such as the number of

steps in a process and the branching found in the process structure are all dimensions

of process complexity which add to the expected effort required to complete a process

(Gribbins et al. 2006). In this study, process complexity is operationalized based on the

categorization of standard or routine types of processes that represent differing

complexity levels (Lillrank, 2003).

The complexity of the process was posited to have a negative impact on task

performance (H5). This was supported by the data in Study 1 where higher levels of

business process complexity had a negative impact on task performance. This was

expected due to the fact that process complexity is related to number of decision points

within a process and also to the expected effort required to complete the process

(Frese, 1978; Gribbins et al., 2006).

The level of complexity of the business process was also expected to moderate

the relationships between task performance and both IT process support and

visualization. It was posited that the positive effect of IT process support on task

performance would be stronger for the more complex process than for the less complex

ones (H7a). Data from Study 1 supports this moderating hypothesis because the participants made higher performance gains in the high complexity treatment conditions when IT process support existed.

It was also posited that the negative effect of visualization on performance would be stronger for the more complex processes than the less complex ones (H8a). However, the results in Study 1 did not reveal any negative effect on task performance in relation to visualization. This is consistent with the findings of (H4) and therefore there was no moderation of the relationship for different levels of process complexity.

In summary, this dissertation indicates that task performance is enhanced through IT process support as established by the automational effects of IT (Mooney et al., 2001). The results also indicate that there is no negative impact when visual displays of the process are shown to the user. Findings show that the more complex the process is, the more likely it will benefit from IT process support.

The Effect of Process Support, Visualization and Complexity on Process Knowledge

Process knowledge was defined in this study as being the degree to which the process participant (user) has assimilated information and knowledge of activities, their flows and the rules associated with the business process. This is considered to be process-related knowledge which is one of three types of knowledge related to processes: process template knowledge, process instance knowledge and process-related knowledge. This type of knowledge can include help files, manuals, regulations and other sources that are usually referred to in order to execute the process correctly.

Process-related knowledge can also be considered in terms of two types of knowledge: knowledge about the process (process knowledge) and knowledge needed in the process (functional knowledge) (Witschel et al., 2010). Sharing process-related knowledge is crucial to maintain efficient performance regardless of employee instability (Witschel et al., 2010). This type of knowledge is also valuable because knowledge about business processes is credited with better work performance (Lee & Strong, 2004). In this study, process related knowledge was operationalized with post-task questions regarding details of the business process.

IT Process Support and Process Knowledge

As part of this study, it was suggested that when business processes are supported by IT, process knowledge decreases (H2). This was supported by the results of studies 1 and 2, and is in line with previous research related to deskilling of employees in the presence of work automation (Attewell & Rule, 1984; Zuboff, 1988). Users tend to rely on the system to guide them through the steps of a process and typically end up with limited knowledge of the process rules. This is likely to have happened in this study as well where the participants realized that they did not have to know the rules to be able to complete the task because the system was calculating and processing the cases based on the built in rules. Notably, the effect size for IT process support is higher in Study 2 than in Study 1. Although I cannot directly compare the effect sizes between the two studies because of a number of differences in the research design, the stronger effect size in Study 2 may point to the fact that IT process support is more likely to lead to deskilling if process training is made voluntary for process

participants. In other words, the results of the studies suggest that adequate process training is likely to partially counteract the negative effect of IT process support on process knowledge.

Process Visualization and Process Knowledge

Visualization of the process map was considered as a way to supply an external representation of the data to improve the cognitive skills of the users and to extend memory (Zhang, 1997). Therefore, it was theorized in this study that visualization would act as a scaffold for acquisition of process related knowledge meaning that the representation of the process map would positively impact process knowledge (H3). The results of Study 1 do not render support to the idea that process knowledge is enhanced when visual depictions of the process map are displayed to users. In Study 2, when training was limited to only system details, process knowledge was found to be indeed positively impacted by the displayed visual depictions of the process, thus offering support to Hypothesis 3. The conflicting results of the two studies can be explained by the fact that training on the details of the process which was provided to participants in Study 1 ensured a sufficient level of process knowledge, which could not be significantly enhanced through visualization. Thus the effect of process visualization might have been diminished in the presence of recent process training. Consequently, the data shows that the process of acquiring important organizational knowledge can be boosted through either mandatory process training or through the availability of a scaffold (in this case, visualization of process map) as theorized in the notion of the zone of proximal development (ZPD) (Vygotsky, 1978; Linn, 2000).

Process Complexity and Process Knowledge

In continuing the investigation of the impact of process characteristics on individual level outcomes, it was hypothesized that process complexity would be negatively related to process knowledge (H6). It was expected that the more complex the process the less process knowledge would be gained. Contrary to that, the results of Study 1 indicate that participants presented with more complex business rules were more knowledgeable about the process after completing the task than participants in the low complexity condition. This may be understood in light of Frese's (1978) review of control and complexity. The contradicted hypothesis may be due to the tradeoff of complexity and boredom as explained by the psychologist, Frese (1978), since low levels of complexity may lead to users' boredom. Accordingly, when users in the higher complexity treatment condition, perceived that the business process was complex, they may have been motivated to learn more about the process. On the other hand, the users in the low complexity treatment condition did not perceive any complexity and may have been bored with the task and not stimulated to learn the associated rules.

Complexity of the process was also expected to moderate the significant relationships between IT process support, visualization and process knowledge respectively (H7b, H8b). The data however did not reveal any support for these hypotheses when studied under the treatment conditions of Study 1 which included full training. In Study 2, levels of process complexity were not varied and therefore could not test these hypotheses. Nevertheless, complexity can also be attributed to several process characteristics; this study has only manipulated one aspect (number of

decisions). Further investigation into other complexity related aspects of a business process are needed to expand the understanding of these relationships.

In summary, this dissertation shows that process knowledge while negatively impacted by IT process support can be enhanced through the availability of a learning scaffold such as a visual depiction of the process map (Linn, 2000). Additionally, it suggests that in the absence of intense training, process knowledge can still be assimilated with the help of proper visual aids that engage a user's cognition (Zhang, 1997; Ware, 2000; Chabris & Kosslyn, 2005). And most importantly, the study also indicates that the presence of such aids will have no negative impact on performance.

Table 22

Summary of Hypotheses Testing in Study 1 and Study 2

Hypothesis	Study 1	Study 2
H1: IT Process support is positively related to task performance (higher productivity and higher accuracy).	Supported	Supported
H2: IT Process support is negatively related to process knowledge.	Supported	Supported
H3: Process visualization is positively related to process knowledge.	Not supported	Supported (alpha=0.1)
H4: Process visualization is negatively related to task performance.	Not supported	Not supported
H5: Process complexity is negatively related to task performance	Supported	Not tested
H6: Process complexity is negatively related to process knowledge	Contradicted	Not tested
H7a: The positive effect of IT process support on performance is stronger for more complex processes than for less complex processes.	Supported	Not tested
H7b: The negative effect of IT process support on process knowledge is stronger for more complex processes than for less complex processes.	Not supported	Not tested
H8a: The negative effect of visualization on performance is stronger for more complex processes than for less complex processes.	Not supported	Not tested
H8b: The positive effect of visualization on process knowledge is stronger for more complex processes than for less complex processes.	Not supported	Not tested

Limitations

As with most research studies, several limitations should be considered before generalization of results can occur. First, I address the experimental nature of the study and the use of students in a hypothetical job setting. Although, I believe the use of students was appropriate for this type of job (entry-level responsibilities associated with processing requests with no authority required), the fact that the subjects only participated for a particular set time contributed to the study limitations. Extending the task period over longer periods of time might be more realistic in nature and generalizable to organizations. Furthermore, the experiment was conducted as an experimental simulation and not a full lab setting which would enable more control over the conditions (McGrath, 1981).

Another limitation of the study is that IT process support and complexity were only manipulated at two levels. Differing levels of IT process support, that would include intermediate levels of support, could offer a better understanding of the overall effects. Process complexity was also only manipulated at two levels (high and low). Varying process complexity levels at multiple levels could also enhance our understanding of the optimal point where IT process support and process visualization could have their greatest impacts. Additionally, Study 2 did not include manipulations of process complexity and was only conducted with a small sample size which is also a limitation of this study.

The personal motivation for participating in the study might have also contributed to the limitations. Although the incentives were designed to enhance motivation of

participation via extra course credit and monetary cash rewards for completing the task both accurately and quickly, not all participants are motivated in the same way.

Contributions to Research

Most of business process research has been conducted at the organizational level as well as business process improvement initiatives (Antonucci, 1997; Venkatesh, 2006; Markus & Grover, 2008). Business process initiatives, however, directly influence individual process participants, and there have been calls for research into the impacts of business process initiatives at the individual level (Venkatesh, 2006). This dissertation shows that configurations such as IT process support and process visualization, as well as characteristics of the business process have potential impacts on individual level process outcomes.

IT support has been studied extensively within decision support systems, particularly in relation to rule support (Turbin & Watkins, 1986; Mao & Benbasat, 2000; Speier & Morris, 2003). The results of the study suggest that IT support can differentially influence different types of individual outcomes. Additionally, the concept of process visualization was included as a possible IT configuration and theorized based on visual cognition and visualization literature. In relation to business processes, visualization provides the ability to perceive patterns linking different components while process maps, in particular, enable a viewer to derive meaning (Ware, 2000; Chabris & Kosslyn, 2005).

Finally, individual-level process outcomes were theorized in relation to both performance and knowledge. While many studies have looked at performance on

different levels (Swink, 1995; Speier & Morris, 2003; Paul et al., 2004; Gable et al., 2008), this study has attempted to enhance the understanding in relation to process knowledge which is an important outcome for organizations (Lee & Strong, 2004; Jung et al. 2007, Witschel et al. 2010).

Contributions to Practice

Business agility of an organization is considered of utmost importance in today's business world (Luftman & Ben-Zvi, 2011). For organizations to be able to make rapid and effective changes, they need to have process performers that are fully knowledgeable about the organization's business processes (Hammer, 2010). IT support of those critical processes has made that knowledge less obvious to the users (Attewell & Rule, 1984; Zuboff ,1988). Additionally, BPM technologies have been geared towards developers and technologists and neglecting end-users which is the basis of the business-IT gap problem (Dreiling, 2010).

Enhancing process knowledge of end users is important to organizations and is considered an important competitive factor (Kock et al. 1997). Additionally, process improvement efforts in organizations cannot be effectively done if important process participants, the users, are not included (Hammer, 2010). However, their input will not be valuable if they lack the necessary process knowledge. The findings of this dissertation suggest that users are able to assimilate important process knowledge when visual displays are incorporated into the system. Additionally, this study indicates that having these visual aids will have no negative impact on task performance, which is

critical to management. Information system designers should be encouraged to include visualization of the process map in light of these findings.

Future Research Directions

Several directions for further research are available and worth exploring. One direction of future research is regarding process improvement initiatives and the engagement of organization employees through the influence of process visualization. Investigation regarding their understanding of the process and ability to make suggestions for further improvements of the business process could offer insight to organizations interested in process improvement initiatives.

Another direction worth pursuing would be to investigate the long term effects of the study's treatments. This could be achieved by carrying out a longitudinal study where the post-task process knowledge questions would be asked after a period of time to investigate the long term effects given that this study mainly focused on the immediate effects (Kuechler & Vaishnavi, 2006).

Complexity can also defined by the number of actors needed to complete the process (Gribbins et al., 2006). I have only manipulated one possible aspect that contributes to complexity of a business process (number of decisions/ branching). It would be worthwhile to look at other aspects related to complexity and testing the proposed relationships when manipulating other features related to complexity. This could potentially include multi-user processes and changing authority roles of users.

Concluding Remarks

This study aimed to address the following research questions:

- o How does IT process support influence individual level process outcomes?

- o How does process visualization influence individual level process outcomes?

- o How do process characteristics (e.g. complexity) influence individual level process outcomes?

- o How do business process characteristics influence the relationship between IT process support, process visualization and process outcomes?

This study was able to offer further support to the notion that IT process support provided by IT has differing impacts on process outcomes. IT support is known to increase productivity and performance and that impact has been supported further for higher levels of complex processes.

Process visualization however is shown to enhance user's process knowledge in the event of no formal process training while having no negative impact on task performance. The key contribution of this research is that it suggests a practical way to counteract potential negative effects of IT process automation by converting the use of the information system into a learning experience, where the IT itself acts as a scaffold for the acquisition of process knowledge. The results have practical implications for the design of workflow automation systems, as well as for process training. This helps organizations keep their competitive advantage. Furthermore, it will enable process performers to contribute effectively to business process improvement initiatives that are important to an organization.

APPENDIX A

SAMPLE SCREENSHOTS OF THE CATERING ORDER ENTRY SYSTEM

Figure A.1. Home screen (all treatments).

Figure A.2. Catering request link (Treatments 1, 2, 3, 4).

Figure A.3. Entry form (Treatments 1 & 5).

Figure A.4. Entry form (Treatments 3 & 7).

Figure A.5. Entry form
(Treatments 2 & 5).

Figure A.6. Entry form
(Treatments 6 & 8).

Figure A.7. Processing view
(Treatments 4 & 8).

Figure A.8. Request log summary (all
treatments).

APPENDIX B

SAMPLE SCREENSHOTS OF THE TRAINING SLIDES

Figure B.1. Task introduction.

Figure B.2. Business process training (high complexity).

Figure B.3. System training.

Figure B.4. System training.

APPENDIX C

MEASUREMENT INSTRUMENTS

Process Knowledge Questions

1. What was the first item that needed to be checked to process the requests?
    a) Requested location availability
    b) Staff requested
    c) Number of guests
    d) Event date
2. What was the offered discount?
    a) 15%
    b) 20%
    c) 10%
    d) No specific discount was offered
3. How much was the delivery service fee?
    a) $20
    b) $30
    c) Depends on the number of guests
    d) No delivery fee was specified
4. When would reserving the on-site location be more expensive?
    a) When there are more than 300 guests
    b) When it is a table service type of event
    c) Never
5. Event day of the week (weekday vs. weekend) impacts:
    a) Number of staff assigned per guest
    b) Menu cost
    c) Hourly wage rate
    d) The day of the event does not impact request processing
6. Is the scheduling of specific employees a part of this business process?
    a) Yes, always
    b) No, never
    c) Sometimes
7. An apology letter is issued when
    a) The guests are more than 200
    b) The on-site location is unavailable
    c) Service staff are unavailable
    d) All of the above
8. How many decision points are there in this process?
    a) 6
    b) 2
    c) 3
    d) None of the above
9. Which of the following does not impact the outcome of the request processing?

a) Event day of the week (weekday vs. weekend)
b) Staff availability
c) Event type
d) None of the above impact the outcome of the request processing
10. Which of the following is a possible outcome of this process?
a) Issue event invitations
b) Issue apology letter
c) Contact catering department
d) All of the above

Perceived System Support and Perceived Complexity Questions

1 = strongly disagree, 2= disagree, 3= neither agree nor disagree, 4= agree, 5= strongly agree

1. Please answer the following questions related to the task of processing a customer request (which you recently performed)

1.1 The system is easy to use	1	2	3	4	5
1.2 Using the system was frustrating	1	2	3	4	5
1.3 Using the system required a lot of effort	1	2	3	4	5
1.4 It was easy for me to use the system	1	2	3	4	5
1.5 The system is useful for processing requests	1	2	3	4	5
1.6 Processing requests using this system is convenient	1	2	3	4	5
1.7 The system allows me to process requests quickly	1	2	3	4	5
1.8 The system is helpful for request processing	1	2	3	4	5

2. The following questions are related to your evaluation of the business process

2.1 The business process is straightforward	1	2	3	4	5
2.2 The business rules for this process were complex	1	2	3	4	5
2.3 The business rules used in the process are simple	1	2	3	4	5
2.4 The business process is complicated	1	2	3	4	5
2.5 The process involves complex business rules	1	2	3	4	5

Demographic Questions

3. Gender: Male   Female

4. Age: 18-21 22-31 32-41 42-55 over 55

5. Classification:

   Freshman   Sophomore   Junior   Senior   Graduate   Other

6. Major:

7. Do you have prior experience in the catering industry?

   Yes   No

APPENDIX D

IRB APPROVAL LETTERS

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Discover the power of ideas.

OFFICE OF THE VICE PRESIDENT FOR RESEARCH AND ECONOMIC DEVELOPMENT

July 12, 2012

Dr. Anna Sidorova
Department of Information Technology and Decision Science
University of North Texas
RE: Human Subjects Application No. 12-343

Dear Dr. Sidorova:

In accordance with 45 CFR Part 46 Section 46.101, your study titled "The Effect of Process Support, Process Visibility and Process Characteristics on Process Outcomes" has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

Enclosed is the consent document with stamped IRB approval. Please copy and **use this form only** for your study subjects.

No changes may be made to your study's procedures or forms without prior written approval from the UNT IRB. Please contact Jordan Harmon, Research Compliance Analyst, ext. 3940, if you wish to make any such changes. Any changes to your procedures or forms after 3 years will require completion of a new IRB application.

We wish you success with your study.

Sincerely,

Patricia L. Kaminski, Ph.D.
Associate Professor
Chair, Institutional Review Board

PK:jh

UNT

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Office of the Vice President of Research and Economic Development
OFFICE OF RESEARCH SERVICES

March 25, 2013

Dr. Anna Sidorova
Student Investigator: Alaa Al Beayeyz
Department of Information Technology and Decision Science
University of North Texas

Institutional Review Board for the Protection of Human Subjects in Research (IRB)
RE: Human Subject Application #12-343

Dear Dr. Sidorova:

The UNT IRB has received your request to modify your study titled "The Effect of Process Support, Process Visibility, and Process Characteristics on Process Outcomes." As required by federal law and regulations governing the use of human subjects in research projects, the UNT IRB has examined the request to modify the data collection instrument, informed consent form and recruitment materials. The modification to this study is hereby approved for use with human subjects.

Please contact Jordan Harmon, Research Compliance Analyst, at (940) 565-3940, or Boyd Herndon, Director of Research Compliance, at (940) 565-3941, if you wish to make changes or need additional information.

Sincerely,

Boyd Herndon for PLK

Patricia L. Kaminski, Ph.D.
Associate Professor
Chair
Institutional Review Board

PK/ jh

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A green light to greatness.™

Office of the Vice President of Research and Economic Development
OFFICE OF RESEARCH SERVICES

June 5, 2013

Dr. Anna Sidorova
Student Investigator: Alaa Al Beayeyz
Department of Information Technology and Decision Science
University of North Texas

Institutional Review Board for the Protection of Human Subjects in Research (IRB)
RE: Human Subject Application #12-343

Dear Dr. Sidorova:

The UNT IRB has received your request to modify your study titled "The Effect of Process Support, Process Visibility and Process Characteristics on Process Outcomes." As required by federal law and regulations governing the use of human subjects in research projects, the UNT IRB has examined the request to modify the informed consent form and data collection instrument. The modification to this study is hereby approved for use with human subjects.

Please contact Jordan Harmon, Research Compliance Analyst, at (940) 565-3940, or Boyd Herndon, Director of Research Compliance, at (940) 565-3941, if you wish to make changes or need additional information.

Sincerely,

Boyd Herndon for PLK

Patricia L. Kaminski, Ph.D.
Associate Professor
Chair
Institutional Review Board

PK/ jh

APPENDIX E

CONSENT NOTICES

Study 1:

<div align="center">

University of North Texas Institutional Review Board

Informed Consent Notice

</div>

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: The Effect of Process Support, Process Visibility and Process Characteristics on Process Outcomes

Student Investigator: Alaa Al Beayeyz, University of North Texas (UNT) Department of Information Technology and Decision Sciences, College of Business. **Supervising Investigator**: Dr. Anna Sidorova.

Purpose of the Study: You are being asked to participate in a research study which involves completing a task related to a business process followed by answering a survey. The purpose of this study is to better understand how business processes should be supported by information technology within organizations. We hope to understand how different information technology support of business processes may impact users.

Study Procedures: You will be asked to go through a short on-line training followed by three questions related to the training. Next, you will be asked to complete a task that involves processing customer requests using the Catering Order Entry System that will take about 5 minutes of your time. You will then be asked to complete an online survey about the task you performed that will take about 15 minutes of your time.

Foreseeable Risks: No foreseeable risks are involved in this study.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to you, but we hope to learn more about systems that support business processes in the real world.

Compensation for Participants: You will receive course credit as compensation for your participation. You may also receive a $5 gift card as compensation for your participation if you are the top performer of the assigned task. The gift card will be awarded during the next class session. An alternative non-research activity for earning the course credit with equivalent time and effort is available; contact your course instructor for more information.

Procedures for Maintaining Confidentiality of Research Records: The confidentiality of your

individual information will be maintained in any publications or presentations regarding this

study. Identifying information and coded survey results will be maintained in separate locations

to protect your anonymity.

Questions about the Study: If you have any questions about the study, you may contact Alaa Al Beayeyz at alaa.albeayeyz@unt.edu or Dr. Anna Sidorova at anna.sidorova@unt.edu.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

Research Participants' Rights:

Your participation in the survey confirms that you have read all of the above and that you agree to all of the following:

- Alaa Al Beayeyz has explained the study to you and you have had an opportunity to contact her with any questions about the study. You have been informed of the possible benefits and the potential risks of the study.
- You understand that you do not have to take part in this study, and your refusal to participate or your decision to withdraw will involve no penalty or loss of rights or benefits. The study personnel may choose to stop your participation at any time.
- Your decision whether to participate or to withdraw from the study will have no effect on your grade or standing in this course.
- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You understand you may print a copy of this form for your records.

Study 2:

<p style="text-align:center">University of North Texas Institutional Review Board</p>

<p style="text-align:center">Informed Consent Notice</p>

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the purpose, benefits and risks of the study and how it will be conducted.

Title of Study: The Effect of Process Support, Process Visibility and Process Characteristics on Process Outcomes

Student Investigator: Alaa Al Beayeyz, University of North Texas (UNT) Department of Information Technology and Decision Sciences, College of Business. **Supervising Investigator**: Dr. Anna Sidorova.

Purpose of the Study: You are being asked to participate in a research study which involves completing a task related to a business process followed by answering a survey. The purpose of this study is to better understand how business processes should be supported by information technology within organizations. We hope to understand how different information technology support of business processes may impact users.

Study Procedures: You will be asked to go through a short on-line training session then you will be asked to complete a task that involves processing customer requests using the Catering Order Entry System. You will then be asked to complete an online survey about the task you performed. Completing the study will take about 30 minutes.

Foreseeable Risks: No foreseeable risks are involved in this study.

Benefits to the Subjects or Others: This study is not expected to be of any direct benefit to you, but we hope to learn more about systems that support business processes in the real world.

Compensation for Participants: You will receive course credit as compensation for your participation. You may also receive a $5 gift card as compensation for your participation if you are the top performer of the assigned task. The gift card will be awarded during the next class session. An alternative non-research activity for earning the course credit with equivalent time and effort is available; contact your course instructor for more information.

Procedures for Maintaining Confidentiality of Research Records: The confidentiality of your

individual information will be maintained in any publications or presentations regarding this

study. Identifying information and coded survey results will be maintained in separate locations

to protect your anonymity.

Questions about the Study: If you have any questions about the study, you may contact Alaa Al Beayeyz at alaa.albeayeyz@unt.edu or Dr. Anna Sidorova at anna.sidorova@unt.edu.

Review for the Protection of Participants: This research study has been reviewed and approved by the UNT Institutional Review Board (IRB). The UNT IRB can be contacted at (940) 565-3940 with any questions regarding the rights of research subjects.

Research Participants' Rights:

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- Alaa Al Beayeyz has explained the study to you and you have had an opportunity to contact her with any questions about the study. You have been informed of the possible benefits and the potential risks of the study.
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- You understand why the study is being conducted and how it will be performed.
- You understand your rights as a research participant and you voluntarily consent to participate in this study.
- You understand you may print a copy of this form for your records.

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