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2005

# Understanding Process Knowledge Change in Enterprise System Implementation: A Framework and Case Study

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# Understanding Process Knowledge Change in Enterprise System Implementation: A Framework and Case Study

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**ABSTRACT**

The adoption of an enterprise system often results in a substantial change of the supported business processes. Research in the area of business process redesign has traditionally focused on performance metrics for measuring process change. However, from the perspective of an employee performing the business process, such measurements are inadequate because they fail to account for the *knowledge* change required for the employee to perform the new process. This paper presents a framework of process change elements from the knowledge perspective. We show how the framework relates to a training knowledge framework proposed by other researchers and discuss its implications for selection of training strategies. We then discuss applications to and preliminary findings from a case study involving enterprise system adoption at the healthcare facility of a large public university.

**Keywords**

Enterprise Systems, Business Process Change, Knowledge Change, Knowledge Management, Training, Learning Transfer

**INTRODUCTION**

As organizations struggle to compete in an increasingly global environment, the adoption of enterprise-wide information management systems is becoming a hallmark of competitive success. With the surge in implementation of enterprise systems comes an increased awareness of the need for adequate training of enterprise system users (Chang, Gable, Smythe and Timbrell 2000; Wheatley 2000). End user training has been recognized as a crucial factor to the success of any information system, but the need for appropriate training in the case of enterprise systems is particularly acute, since these systems redefine the way an organization executes its business processes and provides value to its customers (Davenport, Harris and Cantrell 2004; Nah 2004). This redefinition introduces substantial change in the way employees perform their job tasks, requiring adjustment to new procedures and resources and often a reconceptualization of task steps and objectives. Hence, training in the context of enterprise systems must help employees to cope with and understand these changes, in addition to teaching the syntactic features of the system. As Rajagopalan, et al., (2003) note: "[T]raining for [enterprise] systems is different from that of traditional domain-specific or user-centric information system in that the training has to demonstrate explicitly how various business processes and the knowledge needed to execute them will change under the new system, and how these processes are integrated with other processes to support organizational business drivers."

Despite the substantial process changes introduced by enterprise systems and the need for training to address these changes, current techniques for assessing business process change focus primarily on performance outcomes, such as increased number of orders processed or decreased cost of materials (Harmon 2003). While these measures are informative and valuable, they fail to account for the *knowledge change* faced by a process performer when processes change. In other words, a performer-centric focus on business process change is needed to define the *process knowledge gap* engendered by process redesign. In this context we define process knowledge as knowledge *about* the process: knowledge possessed by the process performer that identifies the process's organization, steps, tasks, sub-tasks, resources, and interaction requirements (Eppler, Seifried and Ropnack 1999). Figure 1 illustrates the concept of the process knowledge gap in the context of enterprise system implementation.

Enterprise System

| Pre - Implementation | Implementation | Post - Implementation |

Creates

Current Process Knowledge

PROCESS KNOWLEDGE GAP

Target Process Knowledge

Process Performer           Process Performer
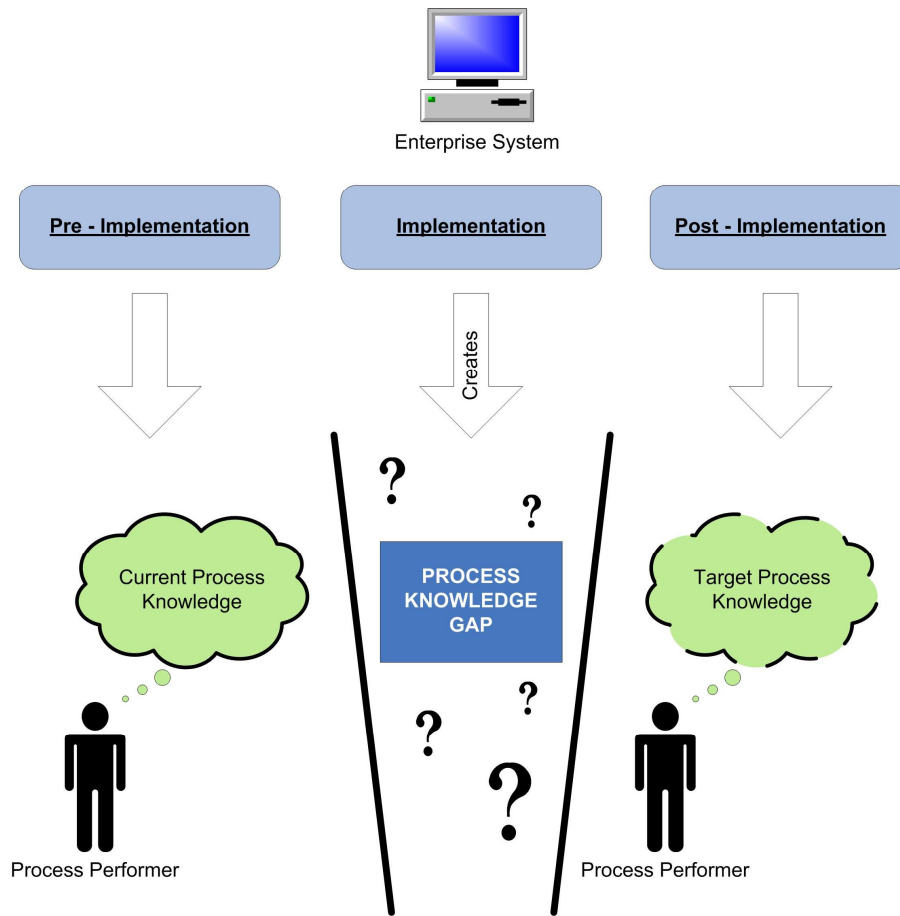
**Figure 1. The Knowledge Gap**

The objective of this research is to develop a framework for assessing the process knowledge gap that results from enterprise system-driven process redesign. The rest of this paper is organized as follows: Section 2 reviews literature in the area of business process change and discusses training research frameworks developed by other researchers. Section 3 outlines the development of a learning-transfer-based theoretical framework for process knowledge change. The framework is then related to a training strategy framework proposed by other training researchers. Preliminary notions of how this framework can be applied in selecting training methods and strategies are discussed. Finally, section 4 presents findings from a case study conducted at the healthcare facility of a large public university.

## LITERATURE REVIEW

### Business Process Change/Redesign

Although processes have always been an integral part of organizations, the full import of process change (*redesign, reengineering)* as a management tool has coalesced in roughly the last decade under extensive research in business process re-engineering (Hammer and Champy 1993; King 1994). The message from this research emphasized that success in BPR efforts hinged on several interconnected elements, including adequate management sponsorship, realistic expectations, collaborative and responsive employees, attention to strategic consideration, and a shared vision of the BPR outcomes. BPR was clearly not as straightforward as its original proponents had indicated. As the BPR phenomenon continued to be examined in the ensuing years, it became apparent that its underlying flaw seemed to be its disregard of human issues. Several studies (Katzenstein and Lerch 2000; Roy, Roy and Bouchard 1998) began to investigate human factors in BPR. This research shift represented a re-acknowledgement of the centrality of humans in business process design and implementation (Palmer 1997).

**Training**

Several studies in both the management and IT literatures have examined factors that influence the effectiveness of training. In order to better understand training practice and research, Sein, Bostrom, and Olfman (1987) proposed a training framework (Figure 2) that identifies the main phases in the training process along with organizational factors that influence training. The training phases included in the framework are: 1) Initiation, 2) Training and Learning, and 3) Post Training. Relevant tasks associated with each phase are depicted in Figure 2.
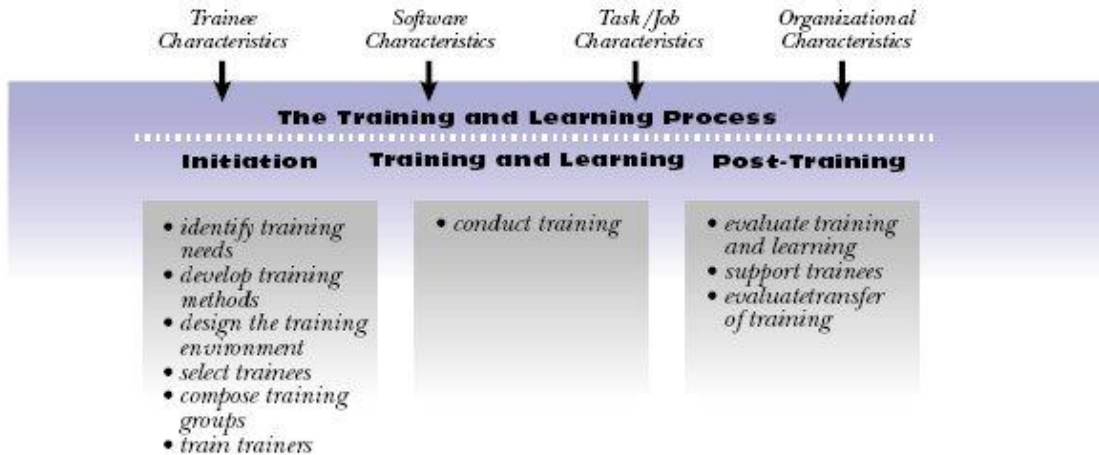


**Figure 2. A Training Process Framework (Compeau, Olfman, Sein and Webster 1995)**

In addition to training phases, the framework recognizes several factors that influence the training and learning process. These include trainee, software, task/job, and organizational characteristics. Past research has focused heavily on trainee characteristics such as learning styles, self-efficacy, computer anxiety, job-career attitudes, personality and other individual-level characteristics that may affect training (Noe and Colquitt 2001). Other studies have examined the training impact of organizational characteristics such as climate (Noe and Wilk 1993), opportunity to perform (Ford, Quinones, Sego and Sorra 1992), organizational justice (Baldwin, Magjuka and Loher 1991; Hicks and Klimoski 1987), and individual versus team context. Less attention, however, has been devoted to the other two factors, particularly task/job characteristics (Compeau et al. 1995; Niederman and Webster 1998). In particular, little has been done to investigate how various types of job/task change influence training strategies and outcomes. This study represents an initial effort in this direction.

**PROCESS KNOWLEDGE CHANGE FRAMEWORK**

As mentioned above, implementation of an enterprise system results in a knowledge change, or gap, between old and new business processes. Employees acquire knowledge/skills that enable them to perform a business processes through training or through experience garnered by repeatedly performing the process. When redesign occurs, the employee must apply (some of) these knowledge/skills to the redesigned process. *Thus, the role of training is to facilitate transfer between the knowledge needed to perform the original process and the knowledge needed to perform the redesigned process.* Edward Thorndike (1901), an early psychologist who studied transfer of knowledge between tasks maintains that the degree of transfer is dependent on the similarity among cognitive *elements* of the tasks. More recent research, supported by developments in representation of cognitive skill, has reexamined Thorndike's theory and attempted to define the notion of *elements.* Singley and Anderson (1989) have applied the ACT* (now ACT-R) theory of learning represent human cognition as a set of production rules: declarative and procedural. Declarative rules capture knowledge of facts or states of being, while procedural rules model knowledge of how a task is performed. ACT-R theory attempts to explain the transfer by the degree to which the production rules (declarative and procedural knowledge) within the two contexts overlap. Applied to the context of process redesign, this overlap, represented in terms of several knowledge elements, represents the "width of the knowledge gap" between original and redesigned processes. If several knowledge elements are similar in both contexts, there is significant overlap and the knowledge gap is small. Conversely, if very few knowledge elements are similar between contexts, there is little overlap and the knowledge gap is large.

**Knowledge Elements that Define the Knowledge Gap**

If transfer between existing and redesigned processes is likely to occur based on the degree of overlap between knowledge elements, the question turns to what these knowledge elements are. Business process modeling incorporates all of the activities involved in transforming *knowledge* about a business system into models that describe the processes performed by organizations (Scholz-Reiter and Stickel 1996). Scores of modeling techniques and methodologies have been developed and utilized over the past several decades. Giaglis (2001) provides an overview of several business process modeling techniques, and suggests that process models represent one or more process perspectives:

- *Functional Perspective (F)***:** Represents *what* process elements (activities) are being performed
- *Behavioral Perspective (B)***:** Represents *when* activities are performed, as well as aspects of *how* they are performed through feedback loops, iteration, decision-making conditions, entry and exit criteria, and so on.
- *Organizational Perspective (O)***:** Represents *where* and *by whom* activities are performed, the physical communication mechanisms used for transfer of entities, and the physical media and locations used for storing entities
- *Informational Perspective (I)***:** Represents the informational entities (data) produced or manipulated by a process and their relationships

These categories constitute a broad classification of the process knowledge components captured by various process modeling techniques. The abstraction of knowledge elements from process modeling techniques is depicted in Figure 3.
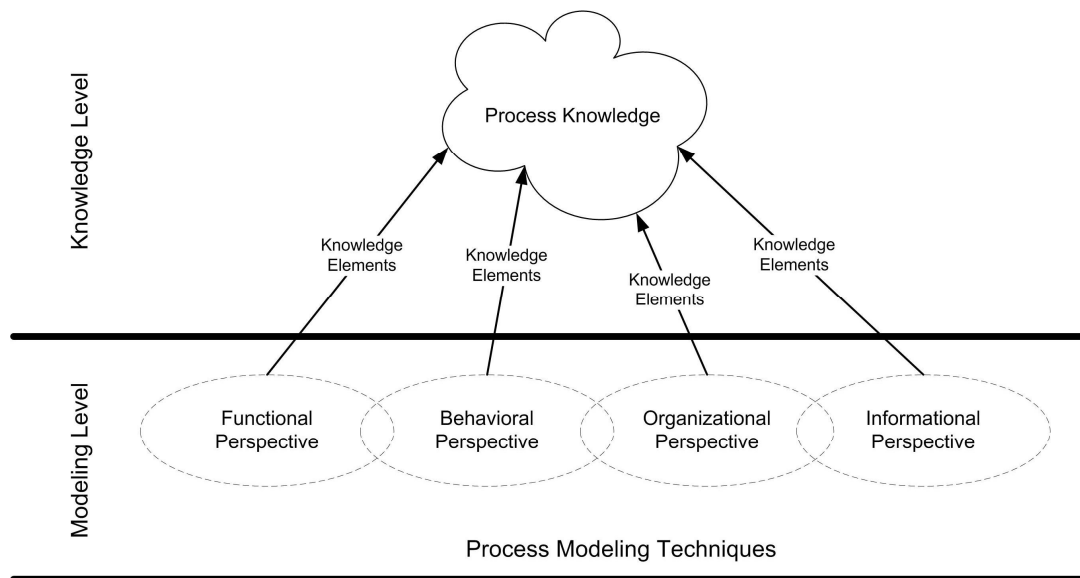


**Figure 3. Abstracting Knowledge Elements from Modeling Techniques**

As Figure 3 illustrates, each modeling perspective contributes to the set of process knowledge elements. The knowledge elements derived from each perspective are represented in a knowledge-centric framework of a process presented in the following section.

**A Knowledge-Centric Process Framework**

The Knowledge-Centric Process Framework (Figure 4) represents the four knowledge categories in the context of an input-processing-output view of the process. From the performer's perspective, the set of inputs and outputs consist of the data flows and stores (informational elements), and resources, internal agents, external agents, and organizational units (organizational elements) that are involved in the execution of the process. This framework represents a change in focus

from traditional IT-based or performance-based process representations, and provides us with a simple but comprehensive picture of the knowledge elements of the process and how they interrelate.
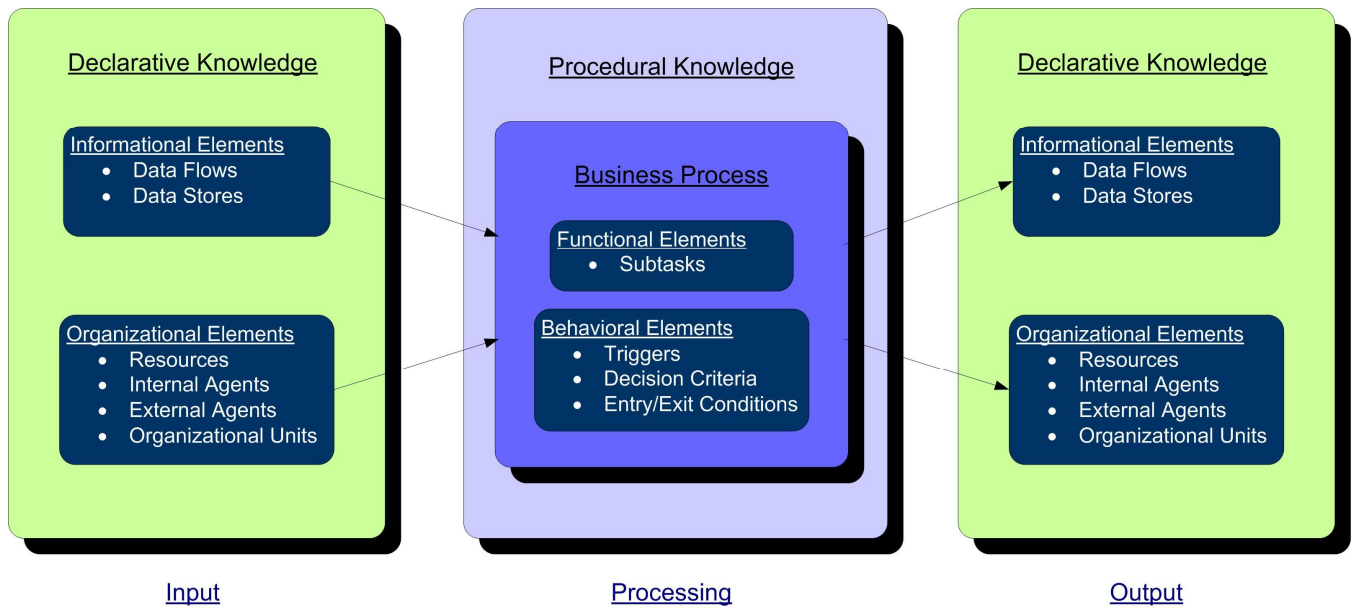


**Figure 4. A Knowledge-Centric Framework of a Business Process**

The Knowledge-Centric framework of business process change adds an important dimension to the Training Process Framework presented earlier (Figure 2).  When enterprise systems are implemented, consideration must be given not only to the task/job characteristics of business performers, but how these characteristics will *change* under the new enterprise system (Davenport et al. 2004).  In other words, training strategies must be designed with an understanding of how trainees' new enterprise system-enabled work tasks will differ from their previous work tasks. The above framework presents a useful and straightforward mechanism for characterizing this change.

The concept of business process knowledge change comes to bear on the selection of training methods and the identification and measurement of appropriate training outcomes.  If a trainee is to utilize the enterprise system to perform his/her work tasks, the trainee must attain a level of knowledge about the system which enables such utilization to take place.  This implies a level of knowledge that includes both how the process is performed and how the system enables its execution.  The next section presents a training strategy framework developed by other researchers that represents the selection of training methods based on trainee and IT tool characteristics, as well as desired knowledge level outcomes.  The training strategy framework is then augmented using the type of process change identified by the knowledge change framework.

**Training Strategy Framework**

Evaluation of training has traditionally focused on skills and behavioral changes in trainees.  Perhaps the most common evaluation framework is that of Kirkpatrick (1959), which proposes that training programs should be evaluated on the basis of 1) Reaction; what the trainees thought of the training program, 2) Learning; what skills, facts, and techniques have been acquired by the trainee, 3) Behavior; how has the performance of the trainee changed, and 4) Results; the impact of the training program on organizational objectives.  This basic framework has been expanded by other researchers to include a host of other factors, such as cognitive and motivational outcomes (Kraiger, Ford and Salas 1993).

In the context of Information Technology, training must address both how the system operates (its syntax and semantics) and how it can be used to accomplish business objectives (its value as a process tool).  Recognizing the need to view IT training

outcomes in terms of trainee knowledge, Sein, Bostrom, and Olfman (1999) proposed a training knowledge level classification that captures knowledge levels to be attained by a trainee. The classification is presented in Table 2.

| Knowledge Level | ERP System Example |
|---|---|
| **1. Command based**<br><br>syntax and semantics of computer tool | Mouse click on a button to enter a transaction |
| **2. Tool Procedural**<br><br>combining commands to do generic tasks | Create a transaction |
| **3. Business Procedural**<br><br>application of a tool to a business process | Query the database for other functional transactions |
| **4. Tool Conceptual**<br><br>the big picture of what to do with the tool | Workflow tool |
| **5. Business Conceptual**<br><br>the big picture of where the specific business process fits into the organization | How entry of a transaction affects order processing |
| **6. Motivational**<br><br>what can the tool do for the trainee and the organization | Enables consistent transactions across organizational functions |
| **7. Meta-cognitive**<br><br>learning to learn | Teach learners to use the learning cycle in exercises |

**Table 1.  Training Knowledge Levels (Sein et al. 1999)**

IT training programs have traditionally focused on the command based and tool procedural knowledge levels, with some emphasis on business procedural aspects as well (Sein et al. 1999). These levels may be adequate for highly localized systems whose impact is limited in scope. However, given the holistic and interdependent nature of enterprise systems, trainees must have an accurate and enabling knowledge of how the use of the tool integrates with the business processes, and how these processes affect the rest of the organization (Bingi, Sharma and Godla 1999). Hence, training programs for enterprise systems must equip trainees with a higher-level conceptual understanding of both the enterprise system and the redesigned business process.

Based on the knowledge level outcomes, Sein, et al., (1999) proposed a training strategy framework to conceptualize the process of designing training strategies in organizational contexts. The framework is a representation of the fundamental question: Given an IT tool on which a specific user type needs to be trained, what training approaches and methods should be used to attain the appropriate level of knowledge? The process knowledge change framework presented earlier enables us to enrich this fundamental question as follows: Given an IT tool on which a specific user type needs to be trained, *and given a specific type of process knowledge change faced by the user*, what training approaches and methods should be used to attain the appropriate level of knowledge? The augmented training strategy framework is illustrated in Figure 5.
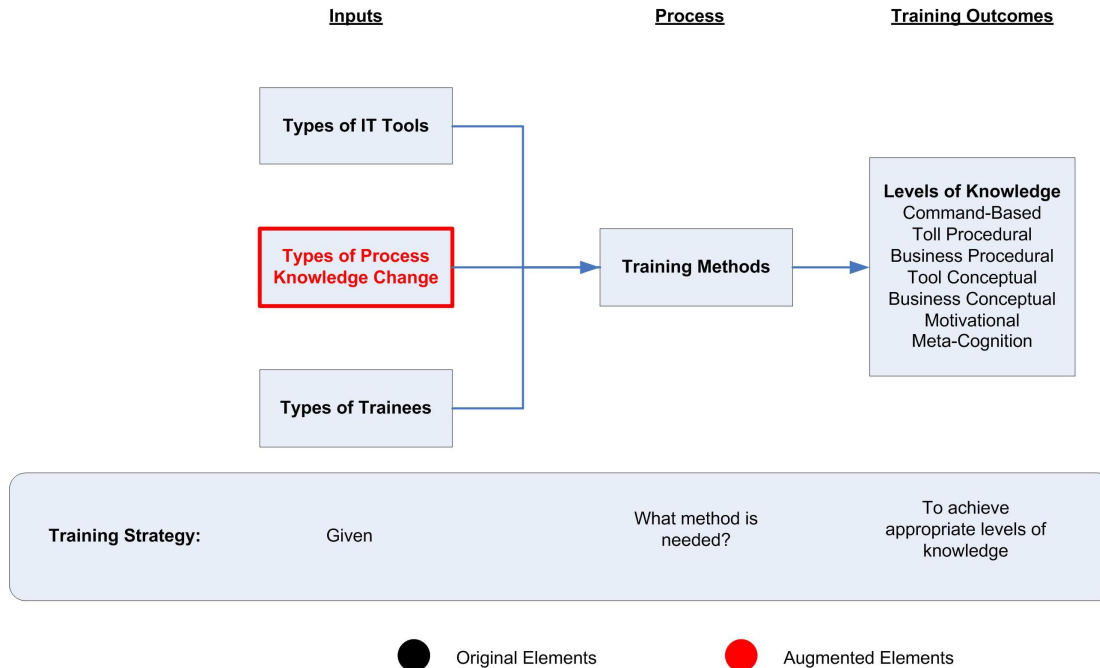
**Figure 5. Augmented Training Strategy Framework**

The augmented training strategy framework highlights the role of the *type of process knowledge change* in helping to determine the appropriate training methods to be used in order to achieve the desired knowledge outcomes. This is an important dimension, since most users of enterprise systems must learn to use these systems in the context of previously acquired and entrenched process knowledge, which may be highly intertwined with their knowledge of prior information systems. Although a comprehensive methodology for selecting appropriate training methods based on types of IT tools, types of trainees, and types of process change is not yet well developed (Sein et al. 1999), we can begin to see how types of process knowledge change may influence the selection of training methods. For example, research in cognitive science has indicated that procedural knowledge is deeply embedded in mental structures and is not amenable to explicit retrieval and description. Thus, a change in procedural knowledge of how to perform a work task will require deeper mental processing, necessitating more interactive and process-oriented training approaches such as hands-on activities and behavioral modeling (Niederman and Webster 1998). Enterprise system implementations are likely to result in many procedural knowledge changes, since processes will be substantially redefined. Recent research has indeed indicated that enterprise system training is more effective when it involves hands-on exercises using the system in business transaction exercises (Noguera and Watson 2004). In contrast, changes that leave procedural aspects largely intact, while altering some declarative aspects of the process, may be adequately addressed by less expensive lecture-based or self-guided online training. Hence, identifying the type of process change faced by the user enables a more accurate prediction of how previous process knowledge and skills will transfer to the new process, and how training interventions can best facilitate this transfer.

Thus far, we have presented a process knowledge change framework based on theories of learning transfer and business process modeling constructs. We then showed how the knowledge change framework can be used to enhance a training strategy framework for selecting training methods based on desired knowledge level outcomes. The validation of the knowledge change framework and its utility in selecting training strategies is a multi-stage progression that will require several studies. In the next section, we outline preliminary findings from an ongoing case study being conducted at health department of a large public university. The purpose of this part of the case study was to determine which of the process knowledge elements outlined in the framework were most significant to process performers in terms of overall process change.

**CASE STUDY**

To provide empirical grounding for our framework, we have conducted a case study at a university Campus Health (CH) organization. CH is a health care facility dedicated to promoting and preserving the health and wellness of university

students, faculty, staff, and affiliates.   CH is organized according to the various functions and services they provide, including patient care, reception/scheduling, lab, pharmacy, radiology, and so forth.   To address various process inefficiencies and remain on the forefront of medical service technology, CH solicited proposals from various commercial vendors for the development and implementation of an integrated Electronic Medical System (EMS).  The new EMS was adopted to overcome current problems of system fragmentation, difficulty of use, lack of control, and high turnaround times.

The EMS is particularly interesting in terms of business process knowledge change because of the highly interdependent nature of the CH business processes and because it unifies processes that were previously carried out on small, disparate information systems.  As with most enterprise systems, the EMS will necessitate alteration of many elements of process knowledge that are essential to carrying out the business processes.

The EMS implementation is being conducted in a series of stages, organized according to functional task groupings.  The first phase to go live was the scheduling portion of the system, which supports the creation of provider appointment schedules, scheduling of patient appointments, and the procedure of checking in a patient upon arrival for an appointment. Several aspects of these tasks were expected to change under the EMS, including the following:

- Tools for creating provider schedules offered much more flexibility and fine tuning capabilities

- The graphical, mouse-driven user interface of the EMS was substantially different from that of the previous system, which was entirely command-key based.

- Because of automated interfaces with other university systems, the EMS obviated the need to verify eligibility information by manually checking these systems.

- Paper encounter forms printed upon patient arrival would no longer be utilized; Providers could enter medical procedure information directly into the EMS system

- Providers would have access to their own schedules and be able to set up their own appointments

- Triage patients could be placed in an electronic 'waiting room' where they could be assigned to the next available triage nurse in a FIFO manner

Even before EMS implementation, our interactions with reception staff indicated that a substantial degree of change was expected in the task of scheduling appointments.  We wanted to decompose this expected change into its constituent components in order to understand the aspects of the expected change that most contributed to perceptions of overall change. This notion was motivated by the concept *process representativenes*, which suggests that some process elements are more representative than others of the composite process in the minds of performers (Leddo and Abelson 1986).  Although receptionists had not yet experienced the change in the scheduling process, they had seen demonstrations of the process under the new EMS, and had been given printed materials outlining the basics of how the system would work.  We felt, therefore, that their knowledge was sufficient to inform their perceptions of how the overall task of scheduling an appointment would change.

### Method

A small pilot group of 7 CH employees was assembled to take part in an open-ended survey about expectations of change in the task of scheduling an appointment.  The group consisted of 3 health care providers, 3 receptionists, and a program coordinator.  Each participant had at least some experience in scheduling patients prior to the EMS implementation, and all were expected to perform the scheduling task under the EMS.  The survey questions probed the respondents' expected changes along the dimensions of the knowledge elements identified in the process knowledge change framework.  For each element, respondents were:

1. Given an example of the element in a familiar work task (a grocery store clerk's process of checking out customers)

2. Asked to identify or describe the element in the current process

3. Asked how they expected the element to change under the new EMS system

The purpose of the second question was to prompt explicit thought about the aspects of the current process such that they could be considered in terms of potential change by the respondents.  The third question aimed to capture how the aspect would change, and was expected to be related to the respondents' perceptions of overall process change.

After the element-based questions, respondents were asked to rate their expectations of overall change in scheduling an appointment on a 5-point Likert scale, with a rating of 1 corresponding to insignificant expected change and a rating of 5 corresponding to significant expected change.

**Results**

Table 2 shows the results of the survey. Table rows correspond to respondent roles: provider (P), receptionist (R), and program coordinator (PC). Table columns correspond to the knowledge elements identified in the framework: subtasks (S), triggers (T), exit conditions (EC), decision making conditions (DMC), internal agents (IA), external agents (EA), organizational units (OU), resources (R), data flows (DF), and data stores (DS). Each element was coded according to its expected degree of change according to the scheme outlined in Table 3. One receptionist answered 'don't know' to each of the element questions and failed to answer the overall change question; hence, this respondent's answers are excluded from the table:

| Role | Knowledge Elements | | | | | | | | | | Overall |
|------|----|----|----|-----|----|----|----|----|----|----|---------|
|      | S  | T  | EC | DMC | IA | EA | OU | PR | DF | DS |         |
| PC   | 3  | 3  | 2  | 2   | 2  | 2  | 1  | 2  | 3  | 3  | 5       |
| R    | 2  | 0  | 1  | 0   | 0  | 0  | 0  | 1  | 0  | 0  | 3       |
| P    | 4  | 2  | 1  | 3   | 2  | 2  | 2  | 2  | 2  | 2  | 5       |
| P    | 3  | 1  | 1  | 1   | 2  | 0  | 3  | 1  | 1  | 1  | 4       |
| P    | 4  | 3  | 2  | 2   | 1  | 1  | 1  | 1  | 2  | 1  | 4       |
| R    | 3  | 1  | 1  | 1   | 1  | 0  | 1  | 1  | 1  | 2  | 4       |

**Table 2.  Survey Results**

| Code | Level | Criteria |
|------|-------|----------|
| 0 | Don't Know | Respondent said she did not know how the element would change |
| 1 | No Change | Respondent said there would be no change, or did not expect one |
| 2 | Little Change | Respondent listed one change and/or or stated that the element might change a little |
| 3 | Moderate Change | Respondent listed two changes and/or stated that moderate change was expected |
| 4 | Substantial Change | Respondent listed more than two changes and/or commented extensively on the expected changes |

**Table 3.  Knowledge Change Coding Scheme**

**Discussion**

Although the results from the pilot survey are based on a small sample that precludes quantitative inferential analysis, we can discern some qualitative insights from the data that shed light on some aspects of expected process change. Of primary note is that while almost all respondents expected moderately significant to significant change in the overall process, there did not seem to be any single or group of knowledge elements that corresponded to this overall change rating. In fact, few element change ratings exceeded even a little expected change. There are a number of reasons why this discrepancy may have been observed:

1.  While no single knowledge element was expected to change, the *combination* of knowledge element changes may have contributed to the high score of overall expected change.

2.  Process performers may not explicitly conceptualize their work tasks in terms of its constituent components. Thus, it may be difficult for performers to consciously identify the elements that contribute most to overall change. This is likely to be particularly true in cases where process knowledge has become highly proceduralized through repetition.

3.  The framework may neglect some aspect of process knowledge change. We are currently investigating how other elements, such as goals and exceptions, may be incorporated into the framework

Of the elements identified in the framework, the one that seems most closely related to perceptions of overall process change is *subtasks*. This seems logical because people often think of their work tasks in terms of the sub-steps required to complete them. Since subtasks are classified as functional knowledge components and constitute procedural process knowledge, it is reasonable to expect that subtask change will result in a higher level of overall process change.

This study has been a first step in elucidating the nature of process knowledge change and how it can be used as an input to the selection of training methods. We are continuing to investigate the framework at CH and other organizations through the use of structured interviews, training observations, and verbal protocol analyses. We expect that the results of these studies will allow us to further refine the framework using well-established techniques for process knowledge elicitation (Liou 1990).

## CONCLUSIONS AND FUTURE RESEARCH

In this paper, we have highlighted the critical need to address knowledge change assessment in the context of enterprise system implementation. Process redesign is an integral part of such implementation, and the literature has suggested that a crucial and often overlooked precondition to successful redesign is consideration of the human impacts of change in the business process. We have, therefore, motivated the consideration of knowledge *about* the process and the importance of measuring the change of such knowledge in process redesign. By relating process knowledge change to theories of learning transfer, we have provided a theoretical basis for understanding the nature of process knowledge and its transfer from one process design to another. Based upon these theories and upon process modeling perspectives, we have developed a knowledge element framework that enables the assessment of knowledge change in process redesign. We have discussed how this framework integrates with a training strategy framework proposed by other researchers, and offered some initial observations about how selection of training methods may be influenced by process knowledge change. Finally, we have presented a case study in which we have begun to explore salient dimensions of process knowledge in the context of an ongoing enterprise system implementation.

This research constitutes a first step in a larger planned research stream. Future research includes:

1.  *Refining and validating the framework.* The framework needs to be further validated in other organizational settings to determine its robustness and to refine the knowledge classification. Because the framework seeks to model knowledge change from a performer's perspective, empirical work comparing knowledge changes identified by the framework and those identified by process performers is needed. In addition, emerging research is proposing other types of process knowledge dimensions that may provide additional understanding for theoretical development (Amaravadi and Lee 2005).
2.  *Relating the framework to training methods:* While it is clear that different types of knowledge change require different training interventions, work needs to be done on matching knowledge change types to specific training methods. This will give the framework prescriptive power in determining the type of training best suited to the type of knowledge change encountered. A methodology for the selection of appropriate training methods based on types of IT tools, types of trainees, and types of process change is not yet well understood. In general training methods should be adopted according to the organization's instructional strategies, which include the set of tools, methods, and content which, taken together, create an instructional approach (Salas and Cannon-Bowers 1997). Although there exist some broad classifications of training methods in the literature along such dimensions as pedagogical approach, delivery method, and setting (Niederman and Webster 1998), a comprehensive framework of training methods has not yet crystallized. In addition, although literature has investigated to some extent the effect of trainee characteristics such as learning style (Bostrom and Olfman 1990; Simon 2000), and characteristics and types of IT tools (Davis and Bostrom 1993; Robey, Ross and Boudreau 2002), there are no prescribed strategies for selecting training methods based on combinations of these factors. Thus, the training strategy framework, while providing a useful infrastructure for training research and practice, requires further refinement and empirical validation.

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