Systèmes d'Information et Management

Volume 11 | Issue 4 Article 2

2006

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R. Baskerville
Departement of Computer Information Systems, Georgia State University, baskerville@acm.org

S. Pawlowski
Department of Inforlation Systems and Decision Science, Louisiana State University, spawlowski@lsu.edu

E. McLean
Departement of Computer Information Systems, Georgia State University, emclean@gsu.edu

ARTICLES DE RECHERCHE

Enterprise Resource Planning and Organizational Knowledge: Patterns of Convergence and Divergence

R. Baskerville[1], S. Pawlowski[2] & E. McLean[3]

[1]Department of Computer Information Systems, Georgia State University, USA
[2]Department of Information Systems and Decision Sciences, Louisiana State University, USA
[3]Department of Computer Information Systems, Georgia State University, USA

ABSTRACT

This paper reports on a qualitative research study to investigate how enterprise resource planning systems impact organizational knowledge. Cognitive mapping methodology was used to capture and analyze the perspectives of senior managers from the IT and user organizations of a major corporation. The results indicate that ERP systems produce effects that make business knowledge become more focused or "convergent" from the perspective of the organization and more wide-ranging or "divergent" from the perspective of the individual. Other important effects include changes to the organization's core competencies and changes in the risk profile regarding the loss of organizational knowledge. The research contributes to the knowledge-based view of enterprise systems.

Key-words: Enterprise resource planning, Knowledge-based view, Organizational knowledge management, Power users.

RÉSUMÉ

Cet article présente une étude qualitative de l'impact des systèmes ERP sur la connaissance organisationnelle. La méthodologie des cartes cognitives est utilisée pour saisir et analyser les points de vue des gestionnaires seniors des organisations TI et des utilisateurs d'une grande entreprise. Les résultats indiquent que les effets engendrés par les systèmes ERP font en sorte que la connaissance organisationnelle est plus concentrée ou « convergente » du point de vue de l'organisation et plus étendue ou « divergente » du point de vue de l'individu. D'autres effets importants incluent des changements dans les compétences de base de l'organisation et des changements dans le profil du risque concernant la perte de la connaissance organisationnelle. Cette recherche contribue à la perspective « fondée sur la connaissance » des systèmes intégrés.

Mots-clés: ERP, Systèmes intégrés de gestion, Approche fondée sur la connaissance, Gestion de la connaissance organisationnelle, Usagers expérimentés.

1. INTRODUCTION

Enterprise resource planning (ERP) systems have become central to the operations of many organizations today. Among the many benefits that firms hope to achieve with the adoption of ERP are tangible returns in higher productivity and reduced operating costs, intangible returns such as improved customer satisfaction, and long-term strategic benefits in growth of market share (Caldas and Wood, 1999; Shang and Seddon, 2000; Gefen and Ragowsky, 2005). Once limited to large organizations because of the significant financial, technical and human resources requirements, options such as preconfigured versions of the software for 'quick start' implementations and ASP-hosted applications have made ERP systems a viable option for many mid-size companies. By 2004 the adoption rate by Fortune 500 firms had reached 80 percent (META Group, 2004). The widespread adoption of ERP systems, however, does not imply certainty in terms of realized benefits. ERP systems still represent a veritable plunge into unknown waters for firms where the near-term success and long-term survival of such systems is difficult to predict. ERP results vary widely from firm to firm (Anderson *et al.*, 2003; Hitt *et al.*, 2002) and the reasons for this variance are only beginning to be identified (Gattiker and Goodhue, 2005). The uncertainties associated with ERP systems begin with the challenges of implementation and extend throughout its lifecycle. IT managers put ERP projects at the top of their list of the most difficult systems development projects (Wilder and Davis, 1998). Post-implementation, the impact on the organization's IT support and maintenance is difficult to predict (Glass, 1998). Even less is known about the long-term effects on the other elements of the organization.

The goal of the research project in this paper is to examine the impacts of an ERP implementation on organizational knowledge. The study is motivated and grounded in the knowledge-based theory of organizations (Grant, 1996b). A fundamental assumption of this perspective is that knowledge capabilities (generation, combination-recombination and exploitation of knowledge) are not only critical for firm performance but can also provide a source of competitive advantage (Conner and Prahalad, 1996; Grant, 1996b; Kogut and Zander, 1996). Given this strategic significance, it is important to gain a better understanding of the ways that ERP systems may impact these capabilities. Initially, important claims in this regard emerged from the practitioner literature. For example, articles debated the effectiveness or ineffectiveness of ERP systems in extracting usable information from the underlying organizational data (Webb, 1999), the role of ERP systems as organizational "knowledge libraries" (Michel, 1998b), or the addition of "bolt-on" ERP modules that incorporate groupware and decision support systems (Michel, 1998a). In addition, in a Delphi survey to identify the major issues in implementing, managing and supporting the ERP lifecycle, knowledge management emerged as the most problematic issue (Chang *et al.*, 2000). Academic research on ERP from a

knowledge perspective has focused on knowledge issues encountered during system implementation such as knowledge transfer and knowledge integration (e.g., Lee and Lee, 2000; Newell *et al.*, 2004; Volkoff *et al.*, 2004; Jones, 2005; Ko *et al.*, 2005) and knowledge barriers related to ERP configuration and assimilation of new work processes (e.g., Boudreau and Robey, 2005; Robey *et al.*, 2002). These studies have not, however, addressed the long-term impacts on organizational knowledge. Our research takes a broader view and examines the impacts of ERP on organizational knowledge that may result from changes in the knowledge requirements of two sets of organization members – the business professionals that are the users of the ERP system and the IT professionals who support the system. As Drucker (1990) has observed, the challenge to organizations is the "integration of specialized knowledges into a common task" (p. 4). This study investigates the ways that ERP may impact the specialized knowledge requirements of organization members in each of these two roles, as well as changes in the relationships between these sets of specialized knowledge.

The research findings contribute to a theory that describes the impact of ERP on organizational knowledge. These findings indicate that ERP systems produce effects that make business knowledge become more focused or "convergent" from the perspective of the organization and more wide-ranging or "divergent" from the perspective of the individual. In addition, other important effects are notable, including changes to the organization's core competencies and changes in the risk profile regarding the loss of organizational knowledge. The study also contributes to the body of empirical research by highlighting the strong interdependencies between information systems, routines and knowledge in an organization. In addition, the case illustrates how radical system change such as the implementation of ERP can potentially impact key knowledge processes (e.g., knowledge sourcing, internal transfer and integration). Finally, the insights provided by this exploratory study point to topics warranting future research.

2. ENTERPRISE SOFTWARE AND THE KNOWLEDGE-BASED VIEW

Enterprise systems (ES) are software solutions, typically provided by a vendor as a package, that provide seamless integration of all information flowing through a company, such as financial, accounting, human resources, supply chain, and customer information (Davenport, 1998). These systems are also known as enterprise wide systems and enterprise resource planning systems (ERP) (Glass, 1998). Major vendors of these commercial systems include SAP, Oracle, Sage Group, Microsoft's Business Solutions Group and SSA Global. As Markus and Tanis (2000) note, the key characteristics of enterprise systems – integrated software, commercial packages, generic processes based on "best practices," additional hardware and software integration requirements, and evolving architectures and functionality – each

have important implications for the organizations that adopt them. The impact of ES adoption is known to be more sweeping: a major cultural transformation that resets basic organizational values regarding discipline, change, and process (Ross, 1998). Based on the findings of a single-site case study, Eriksen, Axline, and Markus (1999) suggest the use of competence centers as an organizational approach to support user education, training and support; retention of business and technical knowledge about the ERP implementation; and support for the technical aspects of ERP software maintenance. Another in-depth case study by Boudreau and Robey (2005) similarly highlights the importance of post-implementation learning by users, including both formal training and improvised learning.

The theoretical framework for investigating the knowledge impacts of ERP systems was drawn from the body of work on the knowledge-based view (KBV) of the firm. While different perspectives are represented in this work (see review in Eisenhardt and Santos (2002)), the underlying assumption is that knowledge is the most strategically significant resource of the firm (Grant, 1996b). For this study, we utilized theory based on Nelson and Winter's (1982) seminal work on evolutionary economics. This theoretical lens was particularly appropriate because of its routines-based view of knowledge in an organization. A routine may be defined as a patterned sequence of learned behavior involving multiple actors linked by relationships of communication and/or authority (Cohen and Bacdayan, 1994). This definition encompasses both "routines in operation" (knowledge used and performed daily) and organizational memory (knowledge that is inert and temporarily dormant repertoires) (Lazaric, 2000). The implementation of an ERP system involves radical changes to routines in an organization, including both of these forms of organizational knowledge. The purpose of this study, then, is to understand the nature of those changes.

3. RESEARCH APPROACH

This is exploratory research aimed at developing theory in the area of ERP and knowledge management. The research design drew together multiple streams of qualitative research methodology. Case methodology was used in formulating the basic empirical infrastructure (Yin, 2002). There were multiple units of analysis including (1) the organization as a whole, (2) the IT department and (3) the collective of internal customers of the IT department. The linking logic was based on repetitive patterns discovered in analysis of the cognitive maps of subjects' reflections on their ERP experience. Semi-structured interviews were conducted and data were collected using audiotape, cognitive mapping, and interviewer field notes. The interview guide was based on a survey of the knowledge management literature. Key knowledge constructs that ERP should affect were identified, and the interview guide was then constructed to probe for effects of ERP on these key knowledge constructs. The interview guide is detailed in the appendix, including the ex-

plicit references to the knowledge management literature from which the concepts were drawn[1].

We adapted *cognitive mapping methodology* as one of the data collection mechanisms and as one of the analytical mechanisms. We operated with a type of cognitive maps known as causal maps, which contain two basic elements: concepts and causal beliefs (Axelrod, 1978). This mapping methodology, which represents cognition as a causal structure, was developed by Eden and colleagues (Eden *et al.*, 1979; Eden, 1988; Eden *et al.*, 1992), and is grounded on Kelly's Personal Construct Theory (Kelly, 1955) as the theoretical underpinning. We adapted a form of cognitive mapping similar to that used for the discovery of a shared "construct system" by a group of people seeking to make sense out of reality (Eden, 1988, p. 2). This construct system is assumed to be hierarchical (some concepts are conceived as subordinate to others).

Along with field notes and audio recording, hand-drawn cognitive maps were created interactively during the interviews[2]. This rich use of maps at the time of data collection enabled the researchers to conduct the initial analysis of individual beliefs about causal structures in parallel with data collection. These maps provided the interviewers with immediate cues for follow-up questions, exploring explanations and consequences of ideas may have surfaced in disconnected ways. In this way, these interview maps were also validated on-the-spot as respondents clarified and expanded their responses and explanations.

Because portions of the original data existed in map form, we continued the use of maps during our *post hoc* analysis and interpretation of the data. We constructed a set of collective cognitive maps at the subgroup (IT and user) and organizational levels that integrated related concepts and links from the individual cognitive maps. Construction and analysis of the cognitive maps were supported using the Decision Explorer software package (Eden and Ackermann, 1998).

As a discovery technique, our *post hoc* use of cognitive maps for interpretive analysis and representation is similar to the soft systems methodology of Checkland (Checkland and Scholes, 1990) because data are sometimes analyzed independently of the subjects (Eden, 1988, pp. 2-3). Unlike uses of cognitive mapping for objectively mapping the causal links of groups for the purpose of decision-making (Eden and Ackermann, 1998), we used causal maps as a tool in an interpretive research mode (Klein and Myers, 1999). Thus, interpretive input from the researcher is incorporated into the final cognitive maps in this type of mapping method (Huff, 1990). Because our research goal involved capturing, analyzing and interpreting the individual beliefs of a small number of senior executives, post hoc group validation of

1. The interview guide used in the field varied slightly in format, for example, the reference details were omitted.
2. There were always two interviewers. One interviewer took traditional field notes, and the other interviewer drew cognitive maps. The interviews were also audiotaped.

the collected interpretive maps by the subject (such as might be necessary in an objective research design) would not be meaningful for the study.

Cognitive maps are graphical representations of this construct system (e.g., see Figure 1). Brief textual representations of concepts are connected together in a diagram[3]. Concepts are linked by arrows that describe explanations and consequences. An arrow into a concept is an explanation. An arrow leaving a concept is a consequence. For example, Concept 19 in the upper left of Figure 1, "Developers no longer design and build software" is explained by Concept 23, "A fundamental shift away from technology and toward business," and as a consequence, Concept 20, "The demand for software skills is diminished."[4]

Our analytic method incorporated elements of the *systematic comparison approach* (Glaser and Strauss, 1967) as an intermediate aid in analysis of the cognitive maps and construction of collective maps (at the sub-group and organization level). This process involved alternating between inductive data reduction to discover concepts and linkages that united the maps (individual, subgroup and organization) and asking deductive questions to compare the emergent collective maps with the initial dataset. (For examples of collective map construction using similar approaches, see Bougon (1992) and Nicolini (1999)). The first step in constructing the collective maps involved creating an initial storyline to help distinguish the relevant concepts and links from those that were less relevant. Audiotape transcriptions of the interviews were examined to identify the core category, or storyline. This storyline was then used as a "seed" framework for the analysis of the individual cognitive maps. The analysis process was supported using Atlas.ti analytical software. This software permitted concepts in the qualitative data to be interpretively assigned into categories. A causal mapping tool is then used to develop the core category storyline by iteratively testing various causal links between the categories until "saturation" is reached – the point where new iterations produce little change to any causal relationships between the categories, especially the core category.

This is a staged research approach. In the first stage, data were collected. In the second stage, an inductive analysis was conducted on a sample of the data and a satisfactory initial storyline (concepts/linkages) was discovered. In the third stage, a holistic interpretive analysis of the individual and emerging collective cognitive maps was conducted to refine this initial model by logically "validating" that the interpretation satisfactorily explained the set of the empirical concepts with no unexplained contradictions.

3.1. Case Overview

The case study was conducted at a *Fortune 100* manufacturing and distribution company with headquarters in Atlanta and operating facilities in the

3. Eden's representation of these concepts permits more powerful two-part constructs, polarized concepts separated by ellipses that rarely appeared in our study.
4. Concept numbers are software-generated for identification purposes only. Letters in parentheses at the end of concept descriptions denote the informant who defined the concept.

U.S. and Canada. SAP R/3 had been implemented in one of the company's major divisions. A subsequent enterprise-wide SAP initiative was later abandoned. At the time of the study, three years after the initial implementation, SAP was about to go "live" in a second major division, in addition to the implementation of a corporate-wide SAP HR system. The objective of this exploratory study was to investigate the impacts of the adoption of enterprise software on organizational knowledge from a high-level strategic perspective.

In order to gain this high-level strategic perspective, we interviewed a small number of very senior executives. These executives included the CIO, three senior mangers from corporate-level functional departments (Customer Service, Production and Inventory Planning, and Accounting) and three senior managers from IT support organizations responsible for implementing the systems. Interview sessions were approximately two hours, and were conducted by two of the authors following a semi-structured format. Interview questions focused primarily on the impacts of the ERP on jobs, working knowledge, and creativity and innovation. We limited our investigation to the senior level in order to focus on the strategic beliefs in the organization, rather than more operational beliefs. This necessarily limited the number of subjects available for study.

4. DATA ANALYSIS

The cognitive maps of all informants were qualitatively analyzed for elements of explanatory stories about ERP and knowledge in the underlying case. Relevant concepts and links were collected into three sub-views or stories across the collective maps. These stories are detailed below. The cognitive map concepts (retrieved directly from the underlying data) related to each element of the story are noted in parentheses.

4.1. Cognitive Map Developer Story

A view of the cognitive map that illustrates the developers' story is shown in Figure 1. This first story line begins with the inability to make blanket changes to the software (27). When the software and the work process requirements don't match, the organization must get creative and come up with a workaround (26). Users and developers have always spent a great deal of time trying to get systems to do something that they hadn't been programmed to do (13); however, without the software modification option, the focus shifts to modification of business processes as a key element of the solution (25). For developers, this means a fundamental shift away from technology development and toward business development (23). This means that the needed skill sets (4) in developers change and they need a deeper knowledge of the company business context and culture (67). There are important shifts in the quality of the developers' jobs (31). Different interests are engaged from the individuals (30); for example, developers no longer direct their creativity toward building technology, but rather toward creatively building business processes (29). The primary focus of developer in-

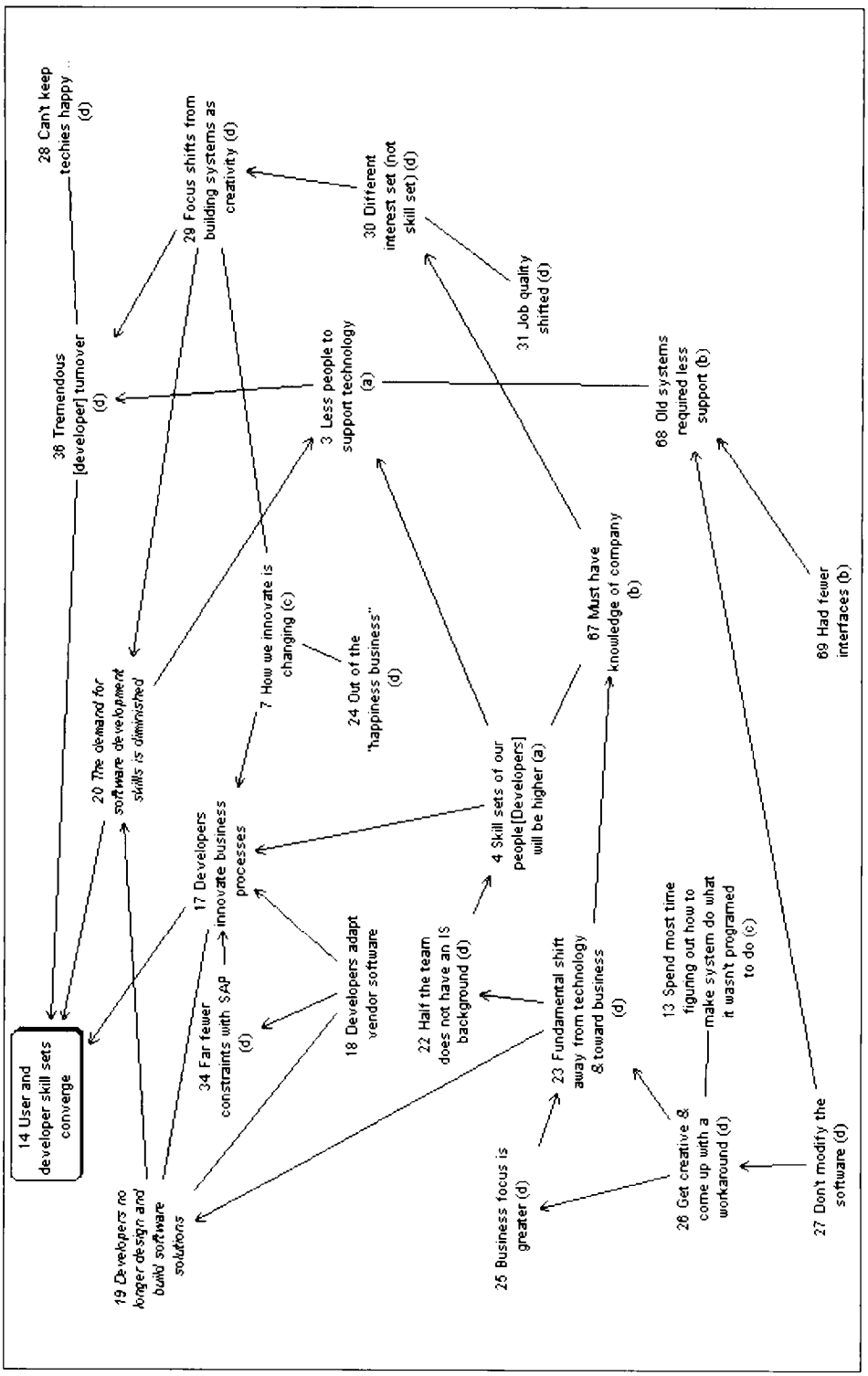

Figure 1: Cognitive map of the developer story.

novation is fundamentally changed (7) as certain primary objectives, e.g., user satisfaction, are transferred from the developer to the vendor (24). Lacking the joy of creative technology development, there is a pattern of voluntary turnover as "computer" programmers leave and become replaced with "business" programmers (28, 36).

The new developer skills are not simply business-oriented, but rather toward combining "package" knowledge and business knowledge. Developers now choose and adapt vendor software (18) and bolt-ons. To some extent, the high quality and versatility of these packages, and the relatively low costs of reconfiguration, place fewer constraints on the developer (34). Consequently, these integrated systems can have more interfaces (69) and may actually require more support (68) than the older, tailor-made systems. Paradoxically, the required support may be more frenzied and visible, but require fewer developers because of the high leverage from the parameterized nature of the support (3).

The net effect is that developers no longer design and build software solutions (19). Instead, developers team with other organizational members to innovate business processes (17).

4.2. Cognitive Map User Story

A view of the cognitive map that illustrates the users' story is shown in Figure 2. The second story line begins with the breadth of analyses available from the enterprise software. The old systems constrained people in the available types of analysis (63). This improved analytical power has two key effects. First, it impacts the skill set of the employees. The opportunity for new types of analysis increases the importance of analytical skills (60, 65). This opportunity also implies increased importance in creativity and innovation for the purposes of discovering the availability and use of such analyses (61). As a result, system users need a different, more wide ranging configuration of talents and skills in order to be effective with the enterprise software (59, 10). Second, the analytical breadth arises in part because the enterprise software dictates an integrated model of the organizational systems to the users. This forced model eliminates the dependence on individual, parochial views of the organization (58, 9, 48). This second effect initiates a profound and contradictory shift in the user culture (2). The improved tools (72) and more satisfying analyses (73) are aspects that potentially raise the quality of work from the users. Contradicting this effect is the increased complexity (40) and the difficulty in preparing for the dramatic transition in ways of working (66).

The users' jobs are more complex because they need both broader technical and business knowledge. The need for broader technical knowledge is a qualitative change. With the old systems, it was more difficult to get the information that was needed (49); the system limited the range of available information. With enterprise systems these technical limits are reduced, and the user's access to information will more likely be limited by their knowledge in two areas. The first area is their technical mastery of the system

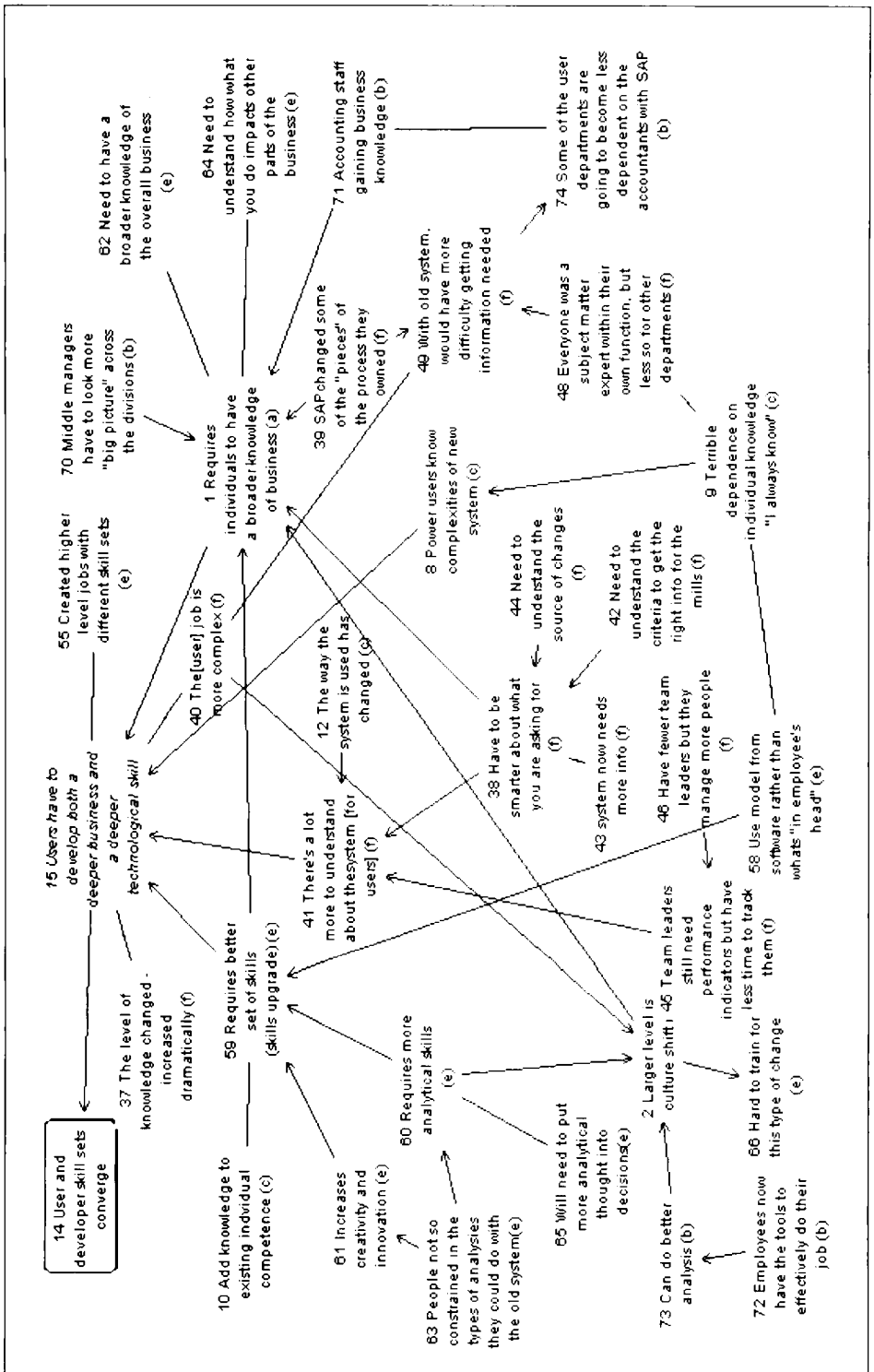

Figure 2: Cognitive map of the user story.

(41); that is, the user's skills at manipulating the software. The second area is the breadth of their working knowledge of the business; that is, the enterprise software changes the pieces of the business system that a user "owns" (39). In order to access a wider scope of information, users need to know more about the business as a whole in order to formulate queries and enter data (44, 42, 43, 38).

Thus users need deeper technical mastery of the enterprise system (41) and deeper business mastery of the underlying business processes (1, 62, 64). This impact extends in like form to supervisory users who now have better tools for measuring organizational performance. These leaders now need better business knowledge in order to judge promptly among measurements and evaluate the results of the chosen measurements (45). Like other users, they also need broader knowledge of the business processes in order to implement these measures (70). In a manner similar to developer support activities, there appears the seeming contradiction of more heightened supervisory activity, yet fewer people needed to carry out the supervision (46). In other words, one outcome of enterprise software is an increase in supervisory activity accompanied by a decrease in the supervisory population.

4.3. Cognitive Map Adaptivity Story

A view of the cognitive map that illustrates the adaptivity story is shown in Figure 3. The third storyline is drawn from much of the same underlying data as the above stories, but follows a different, yet coexisting thread through the concepts. This story regards the ways in which the organization and the individuals adapt to changes in their environments. This story is uniform among users and developers. There are short-term and long-term aspects to this story. The short-term aspect regards the intensive exchange of knowledge during the transition to the enterprise system. One form of this knowledge exchange is between organizational members and external consultants. This concept is regarded as an exchange because the consultants are learning from the local experts almost as often as the internal members are learning from the consultants (11). In addition, the transition process necessitates intensive knowledge exchanges among the internal organizational experts (5).

The long-term aspect is similar to the short-term, but persists after the transition period. There is a fundamental change in the way organizational members learn and innovate (7, 18). This change ultimately affects the ways in which adaptation emerges from the organization (27, 29). The adoption of enterprise software changes the way people transition into, out of, and within the user community in fundamental ways. In seeming contradiction to the increased need for broad technical and business knowledge, the enterprise software may make such transitions easier. The transitions are easier because the software-defined models make training easier (56, 57) and there is less dependence on immediate practical experience (58). The model imposed by the enterprise software motivates the need to learn more about the business, and

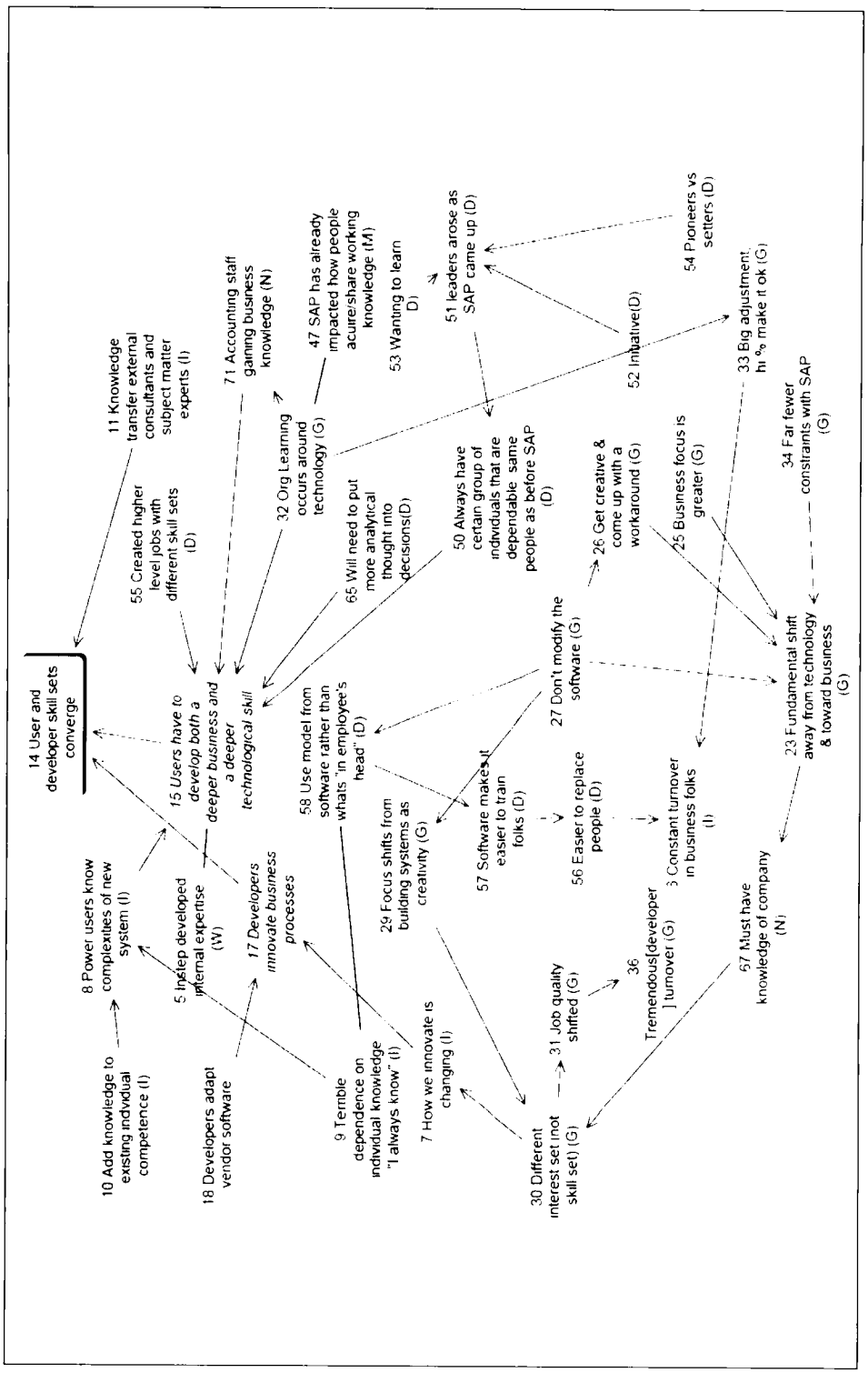

Figure 3: Cognitive map of the adaptivity story.

also mediates the acquisition of this knowledge (47). As we have seen from the previous two stories, this not only affects what people know, but also their skills in learning and mastery of new learning tools (55). The consequence is a natural period of high turnover among both developers and users (6, 36).

Less apparently, but just as critically, organizational learning becomes more centered on the enterprise software (32). There are two noticeable effects in this shift in organizational learning. First is the central dependence on "power users." Power users are self-starting leaders with a quasi-formal role as internal consultants among the users (51). These users act as catalysts in diffusing tacit knowledge within the organization. Importantly, power users are enabling the transfer of contextualized business and analytical knowledge as well as technical knowledge about the software (50). They show other users not only "how" to find information, but "what" information they ought to be seeking. The second noticeable effect of enterprise-software centric organizational learning is the increased turnover in business users (6). This turnover is enabled or induced by the ease of training (57), the ready transfer of tacit knowledge (32), and the big adjustment (33) to critical analytical skills, business knowledge, and technical competence.

5. DISCUSSION: KNOWLEDGE IN THE ERP ORGANIZATION

The implementation of the ERP system triggered an intense period of organizational learning for the firm, entailing radical change to operational routines/organizational knowledge. Not only were prior routines made obsolete, but the new routines ("patterns of interdependent actions involving multiple actors" (Feldman and Pentland, 2003, p. 96)) necessitated by the system were much more tightly coupled and encompassing in terms of the organizational actors and subgroups involved in enacting the routine. These structural changes in organizational routines were reflected in the changes to organizational knowledge seen in the case study findings. One central theme in the stories above is that knowledge in the organization is both converging and diverging (see Table 1). It is clear that knowledge is converging in the organization-wide scope. As a result of ERP, IT development experts need to learn more about the business processes, and business process experts need to learn more about their IT sys-

Organizational group	Knowledge perspective
IT Experts	Our knowledge is ***diverging*** – Now we need to know our technology and more about the business.
Business Experts	Our knowledge is ***diverging*** – Now we need to know our business and more about the technology.
Executive Management	Knowledge in the firm's workforce is ***converging*** – Now employees need to know our business and our technology.

Table 1: A central theme in the stories.

tems. The knowledge of these organizational experts overlaps much more after ERP adoption. From the individual perspective, however, knowledge is becoming more divergent. An expert in customer billing now must learn in more diverse areas than before. Certainly there is a need for more in-depth technical knowledge about the IT systems. But in addition, these subject experts must learn more about other business areas, e.g., production and accounting. Similarly, an IT expert needs more in-depth knowledge about subject areas in the business processes in order to discover ERP system configurations that best serve the organization's goals. Additionally, these experts must learn more about vendor software, e.g., the aftermarket in bolt-on modules, thousands of system parameter options, and ERP programming languages.

There are also central changes in the ways the organization learns. The presence of the ERP system affects the "learning ground" in the organization. To a certain extent, the ERP defines certain key models of organizational process. Use of any model will consequently limit what can be known about reality (Harré, 1972), and ERP models must necessarily frame what business experts will learn about the business processes. The subjects in this study viewed this as an improvement, making it easier to train new people. But the ERP system will also define what business experts need to learn in order to carry out their roles in the business processes, and therefore motivates the activity in the organizational learning ground. Further, the ERP system is a key medium for learning, since it provides a key tool for acquiring information about the day-to-day business activity. In other words, organizational learning is mediated, enabled, and confined by the ERP system.

Another way in which the ERP changes the way organizations learn is by enabling and necessitating the way organizational members innovate. For example, IT developers are no longer innovating with traditional computer program design, but with matching business processes and prescribed IT support. Business subject experts are now routinely innovating in analytical forms rather than operating within the limits of pre-defined analyses. The forms of creativity change and this consequently changes what the organization learns about it environment and its internal processes.

As a result of ERP, the power user has become a central figure in the way organizations learn. The power user is more than just a one-way medium or broker of knowledge about the technology, but has become a multifaceted element in the learning ground. They continue to learn beyond the transitional training. They know more about the technical operation of the system than the IT developers and more about the value of the system in their own business context than the vendor consultants. They have important effects on IT developer learning as well as the learning of other users. The discovery that these users are able to explain not only "how" to use the ERP software, but "why", "when" and "where" to use the software makes these individuals sources, channels, and brokers of tacit

knowledge in ERP systems and business processes.

In itself, the process of the transition to ERP also introduces changes in the way the organization learns. During the transfer of the technology, there is typically a heavy dependence on consultants from the vendor organizations. These consultants mediate, enable and confine the organizational learning about the ERP systems and its inherent constructs for business process structures. The learning ground is initially tripartite: IT developers, vendor consultants, and business subject area experts. Vendor consultants are not merely in a teaching mode, but are also in a learning mode in order to learn enough about the business to configure the software properly (or the business). Thus, the transition to an ERP system is also a learning ground for the vendor consultants. The turnover among consulting staff and among IT developers who achieve expertise in the vendor software is a concern that is raised in the data in this study, but the impact of this particular form of personnel turnover did not surface as a major theme in the analysis.

In addition to the changes in organizational learning, the effects of the ERP transition result in central changes in what the organization knows—the organizational stock of knowledge. The research above indicates that the organizational stock of computer program design and programming knowledge is diminished, while its understanding of a particular vendor ERP and its bolt-on aftermarket is increased. The operating knowledge about organizational business processes becomes more widespread as experience with the ERP grows. In addition, large amounts of this knowledge have also spread to vendor consultants.

At another level, a higher degree of concentration of organizational knowledge is notable. It appears that knowledge about IT support and business process supervision has become more concentrated: the "frenzied few" who are enabled by the ERP software to provide "more" support and supervise "more" people with fewer people at these higher levels. In addition, the critical power user role means a comparatively large amount of organizational and technological knowledge has become informally concentrated in relatively few people.

6. IMPLICATIONS AND FUTURE RESEARCH

There are limitations that constrain this study that provide obvious and interesting avenues for future research. By taking a strategic perspective, our work has focused on the beliefs reflected by a small number of senior executives who share experience with the transition to an ERP in a single large firm. Ours is also an interpretive research design. Follow on work could develop similar results in smaller organizations or at operational levels. Such studies could bring the opportunity to construct an objective study or a study that involves a much larger number of respondents.

The contradiction between simultaneous convergent and divergent knowledge patterns presents fundamentally

different perceptions of knowledge problems at different organizational levels. This contradiction is generally consistent with the introduction of other kinds of advanced information technologies into organizations (Robey and Boudreau, 1999). Further research is needed to fully understand just how the contradictory knowledge patterns ought to be managed.

For example, in our case, divergent and convergent refer to ongoing processes of the way organizations acquire the *dernier cri* of knowledge while obsolescing unneeded knowledge. This process is not just one of broadening knowledge, but also one of replacing knowledge. These processes are inherently strategic because competitive advantage can be found through the specific adaptation of an organization's business processes to those that have been predefined in an ERP (Lee and Lee, 2000). As a result, organizations become more critically dependent on the knowledge of a few experts; a situation in which a small degree of employee turnover can create a strategic disaster.

In this sense, we find that the strategic relationship between organizational knowledge and the introduction of an ERP is rather consistent with previous work in the area. The adoption of these new technologies change the structural frames within which the organization emerges through further innovation and improvisation (Orlikowski, 2000). ERP systems are injected into an organization that is the setting for ongoing social actions. The users and developers must learn new ways to get things done, often by taking action within their changed environment, and realizing that old skills are obsolete, while new skills are now required. Perhaps the changes in organizational knowledge that ensue from the adoption of an ERP constitute an event that means a moment of "radical" structuration preceded and followed by normal, or "incremental" structuration. Further research is needed to explore and understand the contradiction between the knowledge development styles that constitute organizational emergence before and after radical technological introductions like those of an ERP acquisition.

There are also many issues of strategic management for organizational knowledge during transitions to an ERP. The convergence of the knowledge domains of business professionals and IT professionals may point to the need for new knowledge management approaches to facilitate information sharing across the boundaries of these two groups. Such knowledge management strategies could provide significant advantages to organizations that have adopted ERP. This type of knowledge transfer, however, is particularly challenging because of the large gulf between the two communities with respect to both their purpose and their practices (Volkoff *et al.*, 2004). The knowledge to be transferred is "sticky," embedded in individuals, contexts and locations, which can cause transfer to be slow, costly and uncertain (Kogut and Zander, 1993; Szulanski, 1996). Emerging work on boundary spanning/knowledge brokering and information systems (Levina and Vaast, 2005; Pawlowski and Robey, 2004; Volkoff *et al.*, 2004) suggests that these may be critical roles for knowledge trans-

fer during and following ERP implementation. Levina and Vaast (2005), for example, found that users from different organizational units continued in a boundary-spanning role as "boundary-spanners-in-practice" following system implementation, forming an informal, emergent community of practice to share knowledge and coordinate activities across different units of the organization.

One practical implication is the risk involved in the concentration of organizational knowledge in the "frenzied few" and the power users. Coupled with the more widespread operational knowledge of business processes, these findings may mean that ERP has made it easier to replace the "worker bees" (in jobs where the required knowledge has become more explicit/codified), and created "queen bees" (power users with complex, difficult to access knowledge critical to ongoing operations) that are irreplaceable.

ACKNOWLEDGEMENT

We are grateful to our colleague Alina M. Dulipovici for providing the translation for the title, abstract, and keywords.

APPENDIX: INTERVIEW GUIDE (WITH REFERENCES TO KNOWLEDGE MANAGEMENT LITERATURE)

(Background)

Please tell us a little about your personal history, both with this firm and as a professional.

(Enterprise Resource Planning)

1. What motivates your division to undertake ERP? Probe: What were the ERP vision and process objectives? Were these important in determining the right strategy for your division? (Davenport and Short, 1990).

(Knowledge Management)

2. Within your division, is there less or more dependence on the knowledge of your division individuals as a result of the shift to ERP? (Roos and von Krogh, 1996).
   - 2.1. After the ERP implementation is complete, will the need for external consultants within your division, increase, decrease or remain about the same? Probe: How do you see the role of internal experts changing vis a vis external experts? Does the enterprise software "free up" internal expertise for innovation? (Tordoir, 1995).
   - 2.2. Would you expect, that as a result of ERP, the importance of middle management in your division will rise, fall, or remain the same? Probe: How would you expect their role to change? (Nonaka and Takeuchi, 1997).
   - 2.3. Will the adoption of ERP increase or decrease creativity and innovation by employees in your division? Probe: Do you think the need for or nature of creativity and innovation will change? Watch for contamination of Y2K

problems: "innovation on hold". (Graham and Pizzo, 1996).

2.4. Will the ERP change the way people in your division acquire or share their working knowledge? Probe: Does the ERP free up resources, like employee time, for knowledge-oriented activities, knowledge management functions like a CKO? (Jordan and Jones, 1997).

(Knowledge Risk)

3. Will your division have more or fewer strategic opportunities following the shift to ERP? Probe: To what degree have the constraints on your future decisions and strategies been lifted or lowered in your division through the shift to ERP? What kinds of future options are added or eliminated by ERP? (Earl, 1997).

3.1. What areas within your division will have more "programmed" decisions as a result of ERP? What areas will have fewer programmed decisions. Probe: Why? (Nonaka and Takeuchi, 1995).

3.2. What areas within your division will become more dependent on individual knowledge as a result of ERP? What areas will be less dependent on individual knowledge. Probe: Why? (Davenport, 1998).

(General Followup)

4. Does your experience with ERP yield insights for the rest of the organization?

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Richard BASKERVILLE, is a Professor in the Department of Computer Information Systems at the J. Mack Robinson College of Business at Georgia State University. His research specializes in security of information systems and the interaction of information systems and the organization.

Richard Baskerville
Department of Computer Information Systems
Box 4015
Georgia State University
Atlanta, Georgia 30302-4015
USA
Tél. : 404-651-0934
Fax : 404-651-3842
baskerville@acm.org

Nabila BOUKEF CHARKI, Docteur es Sciences de gestion, Université Paris-Dauphine, UMR CNRS n° 7088 Dauphine Recherches en Management (CREPA). Elle est enseignant-chercheur à l'ESDES, GEMO et chercheur associé au CREPA. Ses recherches portent sur le choix de la communication électronique et son utilisation dans l'activité managériale.

Nabila Boukef Charki
Docteur es Sciences de Gestion
Enseignant-chercheur
GEMO, ESDES
23, place Carnot
69286 Lyon Cedex 02, France
Tél. : +33 47 23 50 48
nboukef@univ-catholyon.fr
http//www.crepa.dauphine.fr
www.esdes.fr

François-Xavier de VAUJANY, Maitre de conférences HDR, directeur de Préactis et responsable du master management de projet à l'ISEAG. Ses recherches portent sur la dynamique de structuration des systèmes socio-techniques (notamment des grandes entreprises utilisatrices de technologies de réseau type intranet, groupware, ERP…) et les valeurs stratégiques lui sont liées. Il s'intéresse également à l'étude de ces dynamiques dans une perspective de très long terme de type historique, tout particulièrement pour le cas d'organisations religieuses.

François-Xavier de Vaujany
Préactis
Centre Coactis (EA)
Université Jean Monnet
6, rue Basses des Rives
42023 Saint-Etienne, France
devaujaf@univ-st-etienne.fr

Michel KALIKA, Professeur en sciences de gestion, Université Paris Dauphine, UMR CNRS n° 7088 Dauphine Recherches en Management (CREPA), Directeur du Master recherche e-management. Responsable de l'Observatoire Dauphine-Cegos du e-management. Associate Editor of *Communications of the Association of Information systems* (CAIS). Ses recherches en système d'information portent sur les effets de substitution entre les médias de communication. Il est l'auteur d'ouvrages sur les structures, le management et le e-management.

Michel Kalika
Professeur à l'Université Paris-Dauphine
CREPA
Centre de recherche en Management et Organisation
Université Paris-Dauphine
Place du Maréchal de Lattre de Tassigny
75775 Paris Cedex 16, France
Tél. : +33 1 44 05 49 35
michel.kalika@dauphine.fr
http//www.crepa.dauphine.fr

Ephraim McLEAN, is a Professor of information systems and holder of the George E. Smith Eminent Scholar's Chair in the Department of Computer Information Systems at the J. Mack Robinson College of Business at Georgia State University. Dr. McLean has published over 125 articles in

such publications as the *Harvard Business Review, Sloan Management Review, and California Management Review.*

Ephraim McLean
Department of Computer Information Systems
Box 4015
Georgia State University
Atlanta, Georgia 30302-4015
USA
Tél. : 404-651-3833
Fax : 404-651-3842
emclean@gsu.edu

Suzanne PAWLOWSKI, is an Assistant Professor in the Department of Information Systems and Decision Sciences, E.J. Ourso College of Business Administration at Louisiana State University. Her research focuses on IT and organizational learning and IT professionals.

Suzanne Pawlowski
Department of Information Systems
and Decision Sciences
CEBA 3185
Louisiana State University
Baton Rouge, Louisiana 70803
USA
Tél. : 225-578-2507
Fax : 225-578-2511
spawlowski@lsu.edu

Achevé d'imprimer sur les presses de l'Imprimerie BARNÉOUD
B.P. 44 - 53960 BONCHAMP-LÈS-LAVAL
Dépôt légal : janvier 2007 - N° d'imprimeur : 701091
Imprimé en France