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ENTERPRISE RESOURCE PLANNING AND
ORGANIZATIONAL KNOWLEDGE: PATTERNS
OF CONVERGENCE AND DIVERGENCE

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Abstract
This paper describes a qualitative research project involving a case study that was analyzed using grounded theory and cognitive mapping. It contributes to a theory that describes the impact of enterprise resource planning (ERP) on organizational knowledge. 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.

Keywords: Software packages, software architecture, organizational design, staffing issues, user types, competitive use of IS, enterprise resource planning, knowledge management, business processes, enterprise software, mega-packages, outsourcing, power users

1. INTRODUCTION
Enterprise resource planning systems (ERP) have evolved into a huge and rapidly expanding marketplace, with $16.6 billion in revenues in 1998 and projected revenues of $66.6 billion by 2003 (AMR Research 1999). This represents a veritable plunge by a substantial number of organizations into unknown waters where the near-term success and long-term survival of such systems is difficult to predict. Near-term, IT managers put ERP projects at the top of their list of the most difficult systems development projects (Wilder and Davis 1998). Long-term, the impact on the organization’s IT support and maintenance is unknown (Glass 1998). Even less is known about the long-term effects on the other elements of the organization.

The goal in this research project is to examine the effects of an ERP implementation on business and organizational knowledge from the perspective of knowledge management. Little academic research has been done in this area. However, important claims in this regard are emerging from the practitioner literature. For example, articles debate 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). The focus of this research, however, is to examine 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 who 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.

2. KNOWLEDGE AND ENTERPRISE SOFTWARE

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). Examples of such commercial systems include SAP, BAAN, PeopleSoft, J. D. Edwards, and Oracle. As Markus and Tannis (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, Erikson 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.

Improvements in knowledge management promote those “factors that lead to superior performance: organizational creativity, operational effectiveness, and quality of products and services” (Wiig 1993, p. xv). The term has evolved in the IS literature through links to at least two important IS concepts previously housed within the boundaries of specialized fields. The first concept regards knowledge-base management within the field of expert systems (e.g., Zeleny 1987). The other concept regards the management of knowledge as an organizational resource (e.g., Adler 1989). A working definition of this broader view of organizational knowledge is “information embedded in routines and processes which enable action.” Knowledge is an innately human quality, residing in the living mind because a person must “identify, interpret, and internalize knowledge” (Myers 1996, p. 2).

At least five theoretical concepts underpin knowledge management. Two of these evolve from specialized work in information economics: intellectual capital theory (Roos and von Krogh 1996), important for valuing “soft” organizational assets in accounting and business law; and knowledge economy theory (Tordoir 1995) from specialized research into the economic role of consulting. Three others evolve from organizational strategy research: dumbsizing (Eisenberg 1997), knowledge alliances (Conner and Prahalad 1996), and core competence management (Prahalad and Hamel 1990). “Dumbsizing” refers to rapid and non-linear change (with disregard for lost organizational knowledge) that can undermine sustainable profitability. Knowledge alliances involve strategic alliances with other firms to balance knowledge deficiencies, obtain necessary competencies, or create new knowledge. Core competencies relate strategy to organizational learning. Strategic IS theory regards knowledge as a fundamental resource that enables organizations to compete more effectively in their markets (Earl 1997).

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 1989). 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 audio tape, cognitive mapping, and interviewer field notes. The interview guide was based on a survey of the knowledge management literature. It probed for key knowledge constructs that ERP should affect.
Cognitive mapping methodology was applied in two ways: as one of the data collection mechanisms and as one of the analytical mechanisms. 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).

Hand-drawn maps were created interactively during the interviews. These maps sometimes provided the interviewers with cues for follow-up questions, exploring explanations and consequences of ideas that may have seemed disconnected. Additional cognitive maps were also constructed post hoc from the audio tapes and as analytical representations. After the grounded theory stage, an abstract cognitive map was constructed. This map integrated concepts and links from the grounded theory with related concepts and links from the other cognitive maps. Construction and analysis of the cognitive maps were supported using the Decision Explorer (Eden and Ackermann 1998) software package.

As a discovery technique, our use of cognitive mapping is similar to the soft systems methodology of Checkland (1990) because data are sometimes analyzed independently of the subjects (Eden 1988, pp. 2-3). This form of cognitive mapping is adapted because it is typically used for objectively mapping the causal links of the study subjects for the purpose of decision-making (Eden and Ackermann 1998). In our adaptation, the researchers used causal maps as a tool in an interpretive research mode (Klein and Myers 1999). The cognitive maps thus reflect the subjective interpretation of the researchers.

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. 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.”

Grounded theory methodology (Strauss and Corbin 1990) was used as an intermediate aid in analysis of the cognitive maps. The subjective cognitive map of the interview set was so large that it proved difficult to interpret without an initial storyline to help distinguish the relevant concepts and links from those that were less relevant to a particular theory. Audio-tape transcriptions of the interviews were examined using grounded theory analysis to identify the core category, or storyline. This storyline was then used as a “seed” theory for the cognitive map analysis. Grounded theory 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, a grounded theory analysis was conducted on a sample of the data and a satisfactory theory was discovered. In the third stage, an interpretive analysis of the complete cognitive map was used to validate this theory by logically “proving” that this theory satisfactorily explained the set of the empirical concepts with no unexplained contradictions.

4. CASE OVERVIEW

The case study was conducted at a Fortune 100 manufacturing and distribution company with headquarters in Atlanta and operating facilities in the U.S. and Canada. SAP R/3 had been implemented in one of the company’s major divisions at the end of 1996. A subsequent enterprise-wide SAP initiative was later abandoned. At the time of the study, 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.

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1There were always two interviewers. One interviewer took traditional field notes, while the other interviewer drew cognitive maps. The interviews were also audio taped.

2Eden’s representation of these concepts permits more powerful two-part constructs, polarized concepts separated by ellipses, that rarely appeared in our study.

3Concept numbers are software-generated for identification purposes only. Letters in parentheses at the end of concept descriptions denote the informant who defined the concept.
Figure 1. Cognitive Map of the Developer Story
The CIO, three senior managers 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 were interviewed. 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.

5. 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.

5.1 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 innovation 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 oriented 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).

5.2 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
Figure 2. Cognitive Map of the User Story
access to information will more likely be limited by their knowledge in two areas. The first area is their technical mastery of the system (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.

5.3 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 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.

6. DISCUSSION: KNOWLEDGE IN THE ERP ORGANIZATION

One central theme in the stories above is that knowledge in the organization is both converging and diverging (see Figure 4). 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 systems. 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
Figure 3. Cognitive Map of the Adaptivity Story
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 its 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. Power users 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.

7. IMPLICATIONS AND FUTURE RESEARCH

The convergence of the knowledge domains of business professionals and IT professionals may point to 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.

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” and created “queen bees” that are irreplaceable.

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