A PROCESS VIEW OF ORGANIZATIONAL KNOWLEDGE

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ABSTRACT

Many researchers are of the view that a firm's knowledge assets include its structure, culture, processes, employees and physical artifacts. The Knowledge Management (KM) literature has tended to emphasize *employee knowledge* as a locus for KM efforts. While this viewpoint is perfectly rational and justifiable, there is also a considerable amount of knowledge embedded in the firm's operating procedures. In this paper, we espouse viewing organizational knowledge from this perspective and propose a framework for process knowledge. Starting with a definition, classification of processes, and a characterization of the generation process, we provide seven dimensions by which process knowledge can be viewed: structure, personnel and co-ordination, performance and tools, discourse, results, quality and implications. These are illustrated with examples and implications of the framework are pointed out.

INTRODUCTION

Rapid changes in business and technology are forcing organizations to learn at an unprecedented rate. Many are realizing that unless knowledge collection and transfer occurs at an equally rapid rate, their competitiveness is affected, leading them to focus more intently on their knowledge assets. Though the full specification of the set of these assets is evolving, there seems to be a consensus that they include the organization's employees, structure, culture and processes (Vander Bent et al. '99, Walsh and Ungson '91). Of these, the Knowledge Management (KM) literature has tended to emphasize employee knowledge, particularly tacit knowledge, on the grounds that this is where the "interesting" knowledge resides (Lesser and Wells '99, Lubit '01, Martiny '98). While this viewpoint is probably valid and useful, process knowledge is also an essential part of organizational knowledge and has tremendous significance from a knowledge management perspective. To begin with, organizations have a sizeable intellectual investment in the form of formalizations of processes. Descriptions of manufacturing processes, for instance, include the raw material and equipment used, the appropriate environmental conditions to be realized, the treatment times etc. These descriptions are essential to training employees, establishing standards and communicating best practices within the organization. But they are by no means static. There is an ongoing investment as organizations monitor processes to effect efficiency improvements. Many have mechanisms in place to collect knowledge from the results of processes such as customer surveys, quality control charts and performance audits, which are ultimately utilized to modify the process. Unless this knowledge is structured and organized, it would not be useful. A recent study by the American Productivity and Quality Center

concluded (APQC '97): -- "If you do not have a knowledge management strategy, a framework, and an information technology model to support it … you end up in chaos" ("framework" is underlined for emphasis). It is our objective is to suggest a framework which can aid in accumulating process knowledge. In the remainder of the paper, we define the domain, link it with organizational learning, propose and elaborate on the framework for process knowledge and conclude with discussion of the framework and its research implications. The dimensions form the starting point for organizations wishing to exploit knowledge assets from operations.

DEFINITION AND CLASSIFICATION OF ORGANIZATIONAL PROCESSES

A major part of organizational activity (exceeding 90% in some cases) can be described in terms of processes. A crude definition of a process is as a grouping of related activities (Garvin '97). According to Davenport et al. (1996), a *process* is an ordering of activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action. Pentland (1995) goes as far as to suggest that a process is a grammar for action, prescribing the rules by which activities are assembled together and carried out. We will alternatively use the terms "routine" and "AA (aggregated activity)," OP (organizational process) for referring to processes. Processes typically consist of dozens of activities, each with inputs and outputs. A routine which consists of only one activity is generally not referred to as a process. Teaching for instance, is not a process by this definition. The activities are automated in some cases, while in others they are carried out manually. The inputs and outputs could take the form of materials, personnel, information etc. which vary with the type of process and functional area (Garvin '97). For example, consider the manufacturing, service and design processes listed in *Table 1*.

It is evident that there are major differences in these processes. Manufacturing processes tend to be very structured, dealing with raw material and its transformation to a finished good. They are automated in many cases. Non-manufacturing processes on the other hand, deal with information as a raw material. Cognitive processes such as design involve human beings to a greater extent and tend to be highly individualistic. Process P3 in Table 1 shows how one individual attempted a design problem (Ball et al. '94). The steps followed vary with the individual attempting the problem. Processes also vary greatly from organization to organization and across functional areas. It is beyond the scope of this paper to identify the full set of characteristics of organizational processes since the purpose is simply to identify

the types of knowledge that we can obtain from them. To facilitate this discussion, we introduce a functional classification of OP, based on the framework introduced by Garvin (1997).

Table 1. Examples of manufacturing, service and design processes

P1 – The manufacturing process for Polyamide 6, a Nylon (Wiltzer 2000)
1. Hot liquid caprolactam is conveyed from storage tank 1.1 or 1.2 to Reactor 2.
2. Raw caprolactum from extract water and wastewater containing caprolactam is received by a three-step Extract Water Evaporation.
3. The raw caprolactam undergoes polycondensation in Reactor 1.
4. The caprolactam from Reactor 1 is pumped under pressure into Reactor 2.
5. The polyamide flows from Reactor 2 into Reactor 3 depending on the level.
6. Surplus water is taken off through a reflux column into a sealed pot.
7. The product is extracted and dried after granulation.
P2 -- The Consumer Lending Process (Leath 1998)
1. Origination – application submission, processing, underwriting.
2. Review and booking – reviewing application information, approving the loans.
3. Documentation – maintaining files on the loans.
4. Collection and recovery – pursuing late payments, debt recovery etc.
P3—Design of a tape-position controller (Ball et al., '94)
1. Define functional requirements of device.
2. Define high-level modules.
3. Devise representation of modules and interconnections in block diagram form.
4. Design tape motion sensor.
5. ……..

According to Garvin (ibid), OP could be broadly classified into work processes, behavioral processes and change processes. *Work processes* simply transform inputs to outputs and are synonymous with our definition of a process. These could be broadly classified into *operational* and *administrative* processes depending on whether they are related to production or support it. *Behavioral processes* are patterns of behavior and ways of interacting. *Change processes* are concerned with transforming the organization. Behavioral and change processes are more complex since they include variables from the broader organizational context such as culture, strategies, environmental relationships etc. We expect that while different processes share common characteristics, they will differ in their knowledge requirements. For this reason, we will introduce a classification of work

processes based on the different functional areas of the firm. Accordingly, OP can be classified into: Engineering/design, Manufacturing/service, Financial and accounting, Administrative, Legal and Managerial processes. The classification is based on similarities in inputs and outputs and broadly covers all manner of aggregated organizational activity including, assembling machines, modifying product designs and carrying out performance appraisals.

ORGANIZATIONAL LEARNING AND PROCESS KNOWLEDGE

Different frameworks have been advanced to characterize the *knowledge management cycle* in organizations (Demarest '97, Pearlson '00, Ruggles '98). The major activities in the cycle include identification, generation, codification and transfer. The preliminary stages of identification and generation are concerned with the acquisition of knowledge. Sources of knowledge could be internal or external, including experienced employees, consultants, experts and trade reports. The relevant knowledge is identified and generated through familiar techniques such as discussion groups, presentations, shared workspaces etc. Since we are proposing a framework for knowledge acquisition, we are concerned with the preliminary stages of the cycle in this research.

The generation of process knowledge differs from the generation of tacit knowledge held by employees. The latter is generated through discussion groups, on-line conferencing etc., while explicit process knowledge is generated as a result of conscious management and monitoring of processes. Organizations depend on process improvements for productivity increases. Accordingly, they are continuously fine tuning the parameters of the process such as changing the order of activities, temperature, pressure, ingredients, to increase throughput, quality and efficiency. The process of monitoring and making changes can be characterized as Observe, Analyze, Design, Implement (Kim '93). Thus, when changes are implemented to a process, results are observed and analyzed and improvements made. This process of learning is said to be *single-loop learning (performance loop)*, which occurs when an employee observes *process outputs* and makes modifications to improve them. *Double-loop (relevance loop)* learning occurs when an employee questions the beliefs and assumptions behind the *process set-up* and makes fundamental changes to its structure (Davenport and Beers '95, Hackbarth and Grover '99). For instance, a firm that has traditionally leased equipment could question the *leasing* process and change it by incorporating *sales* as well.

Both types of learning activities require and generate a considerable amount of knowledge, the characterization of which is one of the tasks at hand.

DIMENSIONS OF PROCESS KNOWLEDGE

Knowledge, according to Davenport and Prusak (1998) is "a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. " Knowledge is contextual and includes an actionable summary and interpretation of experience. Similarly, process knowledge is also experiential, contextual and actionable. A process is the result of institutionalization of practice as pointed out earlier and process knowledge is a valuable byproduct of this process. It is contextual since it is difficult to characterize outside of the process. It is embedded in structure, training, management and technologies. Thus *process knowledge* is defined as contextual, experiential, value laden and insightful information about a process, including how it is configured, how it is co-ordinated, how it is executed, what outputs are desirable and what impacts it has on the organization. It is actionable, since the knowledge can be used for training employees, communicating best practices or for effecting improvements. The best way of characterizing this knowledge is to use the input-output metaphor (Depres and Chauvel '00: P75) – What is the knowledge utilized in a process? And what knowledge is generated? To this we add the dimension of *facilitation*, to allow for knowledge that is neither an input nor completely an output. Facilitation knowledge is used to facilitate the process. As illustrated in *figure 1*, the *knowledge inputs* include Personnel and training, Structure of the process, and Management; *knowledge outputs* are results from the process, quality, and implications; *facilitating knowledge* includes performance and tools, discourse and co-ordination (not shown). These are discussed below.

Structural

The structural dimension is concerned with configurations of a process, particularly the orderings of activities which characterize organizational processes. The description of a process enables formation of mental models and is often the main vehicle for knowledge sharing (Leppanen '01). It encompasses the sequence in which activities have to be performed, the inputs and outputs that they have, the constraints under which they are carried out and the manner in which these can be changed to optimize the process. The structural description is vital in manufacturing processes since the parameters and constraints are

stringent. In the manufacture of chemical compounds, for instance, the reaction times, the temperature and pressure, composition of input materials, the type and composition of catalyst used need to be closely adhered to or the firm risks losing the entire batch. On the other hand, in design and managerial processes, there is a greater cognitive component and the opportunity for variations in structure within different groups. Organizations attempt to experiment with process configurations in order to increase throughput, reduce cycle time or increase efficiencies. From a KM perspective, the record and rationale for these changes are a valuable derivative of the learning process, essential in technology transfers.

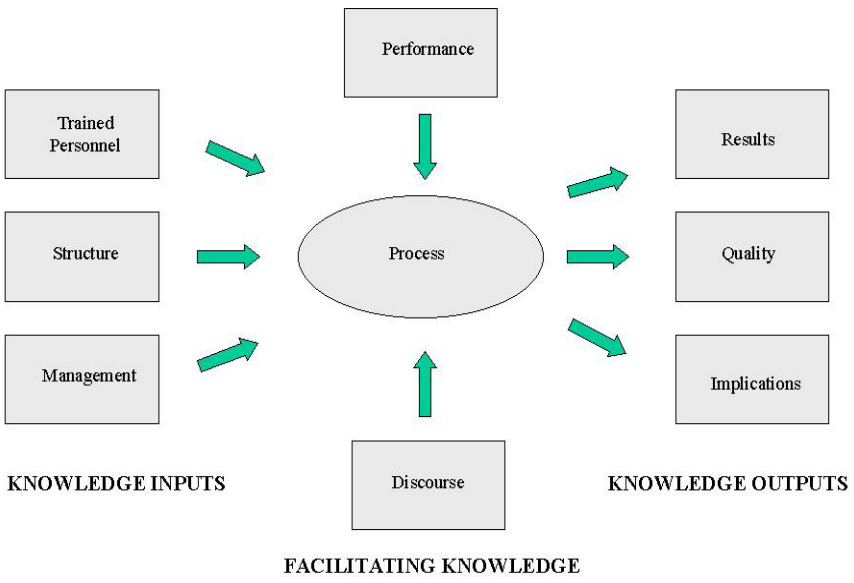

Figure 1. Dimensions of Process Knowledge

Personnel & Co-ordination

In processes where manual intervention is necessary, the company's employees have a very important bearing on the output. "The operators must be very flexible in their problem solving behavior…very ingenious in using all sorts of available knowledge when applicable and their diagnostic performance increases with experience," (Leppanen '01: P 579). Since processes are typically handled by multiple employees, the *personnel and co-ordination* dimensions refer to the training and management that are necessary for the process to achieve

its desired result. Thus it includes issues such as: What are the process expertise requirements? How many individuals are required? How often should they meet? What criteria should be used to evaluate them? How should they be trained? co-ordinated. For how long should employees be trained? How should they be co-ordinated? What development programs have been carried out and what are the results of these programs?

Performance & Tools

Knowledge is both required and generated as a result of process execution. The performance dimension is concerned with knowledge associated with the execution of the process and tools used. Included under this rubric is knowledge about the factors which affect the efficiency and throughput, the type of problems that arise and their resolution, the support tools and their idiosyncracies. One example of this type of knowledge (in a fast food restaurant) is a method of distributing pepperoni on deep-dish pizzas so that it overcomes the problem of "clumping," where all the pepperoni gathers in the middle. The solution to even-distribution is to arrange the pepperoni in the form of spokes, on the pizza, before placing them in the oven (Argote '99: p 91). This dimension is also very significant in manufacturing processes.

Discourse

Certain types of processes such as strategy formulation and design are iterative and involve considerable amount of negotiation and discourse, to obtain ideas, surface problems, obtain additional information, resolve issues and arrive at a consensus. The process of arriving at decisions through discussion and negotiation is called *due process* (Hewitt '86, Gerson and Star '86). Due process is time consuming, involves multiple parties and considerable amount of discussion. Hiring the CEO of a company is such an example since it is a lengthy process involving the board, the personnel department and top management of the company with each group having different views. Due process also generates knowledge about the history leading upto a decision: the rationale behind decisions, the time frames, the key actors, the alternatives considered and the compromises that were made (ibid). This type of knowledge is necessary to evaluate or trouble shoot processes or to make deeper adjustments (incorporate double loop learning) to them.

Results

The *results* dimension concerns two types of knowledge, the outcomes of a process being executed and results concerning its effectiveness. For instance, in a loan situation, the amount of the loan issued as associated with the type of customer is an example of the former type of knowledge. Actually, it would become knowledge only when analyzed over a period of time over a large number of customers (Hackbarth and Grover, '99). Patterns such as the type of customers, average loan amounts etc. can then be discerned. The second type of knowledge concerns results of *process measures* i.e. "performance loop" type information. In the loan situation, these can include the number of "touch points" (the number of times the bank handles a particular application), the amount of time it took to process the loan, the number of writeoffs (due to non-payment) etc.

Quality and Objectives

For manufacturing and service processes, product quality is one of the important, albeit intangible outputs of a process. The *quality* dimension is concerned with quality of the process and its outcome. It encompasses knowledge about quality indicators, their current and target values, and with techniques to improve quality. Quality indicators include such things as timeliness, cost, quantity etc. This dimension has some overlap with the tools and performance dimension. For non-manufacturing processes, quality may not be relevant and therefore we have also included the label of *objectives* to encompass the requirements to be met by administrative and managerial processes. It can include such things as minimizing claim amounts (in claims processing) or hiring a CEO by a certain date (in a hiring process).

Impacts and Implications

Processes are typically interlinked with other processes such that changes to one has important implications for other activities within the organization. In fact, these are often the critical processes in the organization (Lientz and Rea '98). Design and managerial processes are cases in point since they are concerned with key decisions that drive other OP. The re-design of an engine could require re-tooling of assembly plants, modification to components that are purchased, and perhaps changes in supplier relationships as well. Similarly, when a company decides to issue stock, it is obligated to inform the SEC (Securities and Exchange Commission) and its shareholders. The implications dimension is thus concerned with implications for organizational action. As with the results dimension, there are two types of

implications corresponding to the two types of learning. The results of a process could have implications for making adjustments to the process or for making changes to other activities. It should be evident that this dimension comes into play when modifying existing OP or designing new OP based on existing processes.

KNOWLEDGE DIMENSIONS AND PROCESS TYPES

Rather than to simply view processes as operational or administrative, we've attempted to classify them into engineering/design, manufacturing/service, financial/accounting, administrative, legal and managerial since these processes deal with fundamentally different sets of inputs, outputs and constraints. The knowledge dimensions that are relevant for a particular process type will depend on whether or not the process is critical, involves considerable amount of co-ordination and well defined (i.e. measurable) outputs. As shown in *Table 2*, for *manufacturing processes*, dimensions such as structure, personnel, performance, results and quality are very relevant while the discourse dimension and impacts dimensions are not very relevant. For *administrative, financial and legal processes*, the structure, personnel, performance, discourse and results dimensions are very pertinent. On the other hand, for *managerial processes*, the relevant dimensions are the discourse, results and impacts, while other dimensions are not so relevant. In the following, we give additional examples of O.P. and identify some of the relevant items of knowledge. (please note that examples of the structural dimension have already been given in *Table 1*).

Industrial process -- *Performance dimension*

In an industrial process to strip Hydrogen Sulfide (H_2S) from waste gases, consider the following description which fits in with the performance dimension (Anonymous '01:p35): "In cases where flaring will not reduce H_2S concentration sufficiently to meet the emission limit, ….other treatment methods must be used. These include iron sponges (and other iron-baed absorbents), chemical scrubbers and water scrubbers. A recently completed research and development project… determined that an iron oxide-based adsorption medium –Media G2- could efficiently and cost-effectively remove H_2S from biogas." The extract describes how H_2S can be removed from waste gases and is therefore an example of the performance dimension.

Consumer lending process – *Personnel dimension*

A study of ten financial institutions identified a number of best practices in the lending process. Among them, the study found that "..in addition to the delinquency rate, focusing on the cure rate and loan portfolio were the optimal ways to determine an individual collector's productivity." -- (Leath '98: p38). As described in the case, the "cure rate" is an effective method of evaluating loan collectors and illustrates one aspect of the personnel dimension.

Table 2. Process types and Dimensions

PROCESS TYPE	EXAMPLES	RELEVANT DIMENSIONS
Engineering/Design	Furnace setup, boiler inspection, new product development.	Discourse, Results, Impacts & Implications.
Manufacturing/Service	Manufacturing Nylon, Assembling mother boards.	Structural, Personnel/Co-ordination, Performance & tools, Results, Quality.
Financial/Accounting	Preparing financial statements, Auditing.	Structural, Performance & tools, Results, Impacts & Implications.
Administrative	Hiring employees, buying equipment.	Structural, Personnel/Co-ordination, Performance & tools, Discourse, Results.
Legal	Issuing stock, preparing labor contract.	Structural, Personnel/Co-ordination, Performance & tools, Discourse, Results, Impacts & Implications.
Managerial	Strategic planning, negotiating a supplier contract.	Discourse, Results, Impacts & Implications.

Purchasing process – *Co-ordination dimension*

The following is an illustration of the co-ordination dimension in the U.K. food service industry: "The catering review group meets every six weeks and is used as a vehicle to co-ordinate the operational fulfillment of consumer requirements at site level. This review group consists of the marketing manager,. …The review group acts as a forum for discussion but also has the power to veto or ratify a proposal. This decision is made by consensus...." -- (Mawson and Fearne '96:p39). The constitution and operation of the group is illustrative of one aspect of the co-ordination dimension although effective interaction techniques would be a more valued component.

Customer service process – *Quality dimension*

A major computer manufacturer uses the following measures for monitoring its customer service process (Adapted from Davenport and Beers '95): % of product returns (2%), % of orders delivered on-time (99%), # of calls answered per day (2400), # of calls abandoned (80), amount of waiting time for callers (5 min). The number in brackets indicate acceptable values of these indicators and are illustrative of the quality dimension.

Engineering design – *Results dimension*

The following is a hypothetical example of the results dimension: "A car manufacturer found that engineering and development of a new model cost $1,000,000 with $250,000 spent on development and the rest on tooling. The process required twenty five engineers, a hundred indirect employees and three years to complete." If this information were linked with sales of the car, there is an opportunity for evaluating the effectiveness of the process.

These rudimentary examples bear out the hypothesis that process knowledge can have several dimensions, of which some are salient in certain types of processes, and that tapping it can be of utility in communications, process design, training etc. The framework has several implications which are discussed next.

DISCUSSION AND IMPLICATIONS

We have considered process dimensions from a *knowledge management perspective*, although other perspectives have been presented in the literature. There has been an extensive body of literature considering processes from an *engineering,* i.e. workflow automation (Stohr and Zhao '01) and *re-engineering standpoint* i.e. BPR (Business Process Re-engineering) (Davenport et al. '96). In workflow automation, the emphasis is on modeling the structure of the process and automating it with software. Issues such as activities, their constraints, dependencies and authorizations are considered (Stohr and Zhao '01). In BPR, the objective is specifically to achieve process improvements. There is a special emphasis on identifying critical processes, developing measures, assessing their performance, making improvements, and assessing the costs and benefits (Gardner '01, Lientz and Rea '98). Despite sharing the same objectives (process improvement) and overlap in the information analyzed, (in the structural and quality dimensions), these perspectives are

not intended to tap process knowledge as we have attempted to do and besides lack holistic approaches to it.

In attempting to provide a KM perspective, we have avoided labels such as outputs (subsumed by structure and results), costs (also subsumed by results), productivity (same) work-in-progress (not considered) and status (not considered) which could potentially communicate a data orientation. We have also not considered process evaluation (subsumed by implications), functional knowledge (subsumed by tacit employee knowledge). Instead, we simply focused on the knowledge inputs (such as structure and management) and outputs (such as results and implications*)* of processes. Whether the labels are justified and whether or not they are adequate is difficult to validate in an empirical sense because of the qualitative nature of the framework. They can however, be refined experientially by being applied in various organizations, for various types of processes.

The framework provides a starting point for organizations in *assessing* knowledge resources that are in the process form. In order to actually identify the knowledge, a more detailed characterization as it pertains to each dimension is required. (This has been carried out to some extent in the paper, although not formally). Whether or not such a characterization can be carried out with the KM perspective intact is debatable. The structural dimension has been characterized as inputs, steps, outputs and constraints, but this has little value except in the fully interconnected form, because this is the nature of knowledge. Consider the following description of an assembly process (Garg '99: P419): "Board1 and Board 2 are assembled along with other parts into modules of type A. Type B modules are manufactured at a different site. The Marry Station …. loads special software that enables type A and type B modules to work together. However, by redesigning these modules, this operation can be eliminated altogether." Clearly, structural knowledge is intertwined with the inputs, outputs and operations. Communicating this knowledge is not possible without the use of process charts. Even if it were useful, it may not constitute knowledge to a production manager, who might be more interested in aggregate characteristics such as throughputs and capacities. As another example, the discourse dimension can be characterized as issues (can these be clearly distinguished?), actors, viewpoints and time periods. This perspective can yield information on what a particular actor may have said at a particular time, but not necessarily his/her motivation or objectives, which have to be evaluated based on the entire discourse. Utility aside, each of the dimensions is also complex and interrelated. For instance, there is overlap

between the structural, quality and performance dimensions because increasing quality will require changes to the tooling and the way activities are carried out. Similarly, the quality dimension can encompass measures for each activity of the process, which could vary with the type of product. A detailed characterization of process knowledge could potentially be problematic, unless the context of the entire process were somehow preserved and individual items of knowledge were presented within that context (See also APQC '97). This responsibility rests with designers of KM systems.

The design of effective KM systems is contingent to a large degree on the existence of effective methodologies and tools. *Methodologies* are techniques for modeling process knowledge, and can encompass petri-nets, discourse-maps, cause-maps etc. *Tools* are software programs that embody such methodologies. Both of these are major gaps in the literature. Discussions of methodologies and tools (Wensley and Verwijk-O'Sullivan '00) have been sparse and too broad for the purpose at hand. It is necessary to assess and if needed, develop tools and methodologies to support the acquisition activity. It is expected that there will be well-developed tools (see Stohr and Zhao '01, Amaravadi '98) for the structural and discourse dimensions, but for other dimensions, techniques from Artificial Intelligence (see Amaravadi '01) may have to be utilized. It is also expected that the methodologies will have to be tailored for each type of process. Indeed, the development of effective knowledge management systems is one of the principal goals of the KM community which can greatly benefit from improved codification techniques. This is even more critical in the case of process knowledge.

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