Applying Systems Thinking in the Evaluation of Organizational Learning and Knowledge Creation

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ABSTRACT

Organizational learning and ability continuously create new knowledge are important factors in achieving sustainable competitive advantage. It is important that the environment for learning and knowledge creation is analyzed in order to direct development efforts towards right areas. This can be very difficult because organization's environment is of highly abstract nature. In this paper, we present a new kind of co-expert system which can be used to form a bottom-up view of organization's learning and knowledge-creating environment. With the help of this co-expert system a new kind of meta-classification to the responsive environment for learning and knowledge creation is formed. This new methodology can be used to capture a systemic view of organization's environment. The first preliminary tests of the system have also been made.

Keywords: Organization, Learning, Knowledge Creation, Responsive Environment, Co-Expert System.

1. INTRODUCTION

In today's business environment changes take place at an accelerated pace. According to de Geus [1] the world of business has shifted from one dominated by capital to one dominated by knowledge. Organizations must develop human resources and enhance the amount of information and knowledge available in order to differentiate from other organizations [2]. People and the knowledge they carry in their heads are highly valuable resources for companies [1]. Knowledge and know-how are strategic resources of an enterprise which have to be managed and developed [3]. Therefore the interest in organizational learning and knowledge creation has emerged rapidly during the last few years.

Organizations typically have their own unique characteristics that define the environment in which employees carry out their responsibilities. This environment reflects the organization's culture. In our view, this environment can be either restrictive or responsive from the vantage point of learning and knowledge creation. Therefore it is important to analyze the organization's environment in order to develop the organization in a more responsive direction. According to Kessels [4] the traditional approaches to management, training and development will not provide the learning environment required for knowledge work. This environment is very difficult to analyze because of its highly intangible nature. In this development process a clear systematic view of the organization's environment is needed in order to direct development efforts towards those areas where the real value creation exists.

In this paper, we present a new class of co-expert system that provides for a systematic evaluation and development of the responsive learning and knowledge-creating environment. The name 'co-expert' refers to an interactive decision support system that incorporates a bottom-up, collaborative and coaching view from the "real-experts", i.e. the learning environment users. The bottom-up view is important because in only this way can the real understanding of day-to-day practices up to management level be achieved. The system has three different levels: 1) a practical level, 2) a system level and 3) a meta-level. A co-operative view is used to interpret the current reality within the organization, i.e. on the practical level. The system level, in turn, converts the practical bottom-up view into different classifications and to the meta-level understanding. In this way it is possible to gain a systemic view of an organization's environment for learning and knowledge creation.

The developed co-expert system, called *Lituus,* is one of the Evolute -applications. The development of *Lituus* is based on theories that have been collected into a solid theoretical framework - Evolute theories, by Tampere University of Technology at Pori. At the core of Evolute- theories we find the Circles of Mind Metaphor [5] for constructing real conscious experience. Some of the supporting theories are the Holistic Concept of Man (HCM) [6], Ford's formula for human behaviour [7], Tannenbaum's classification of a learning environment [8], Nonaka & Takeuchi's knowledge creation spiral [9], Miller's living systems thinking [10] and Checkland's information systems theories [11].

2. ORGANIZATIONS AS LIVING SYSTEMS

In our research we treat organizations as living systems to get a systematic view of their functions and structure. Miller's theory of living systems analyzes the structure and process of the living system's seven hierarchical levels [10]. These levels are: cell, organ, organism, group, organization, society and supranational system. According to Miller [10] the systems have at each level 19 subsystems which process inputs, throughputs and outputs of various forms of matter, energy and information. Nonaka and Takeuchi [9] also treat organizations as living organisms instead of seeing them only as information processing machines. They also argue that highly subjective insights, intuitions and hunches are integral part of knowledge. Based on the living systems theory Samuelson [12;13] has presented a model of the living system's behaviour (Figure 1).

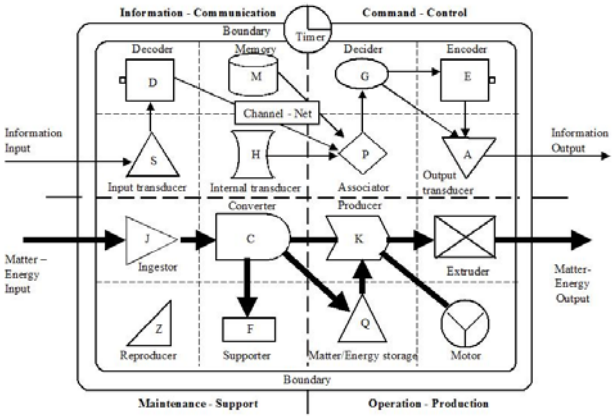

Figure 1: The living system and subsystem functions [14;12;13].

In Figure 1, (reconstructed by Österlund), the upper left section consists of those functions dealing with the living system's information and communication. The upper right section consists of those functions dealing with the living system's command and control. The left side of the lower section consists of those functions dealing with the living system's maintenance and support. In turn, the lower right side consists of those functions dealing with the living system's operation and production. Together these four sections also form the general concepts of organizational management: to keep and maintain a functioning system. In this paper, we present a responsive environment, a system, for learning and knowledge creation which is based on this important division between information - communication management, command - control management, maintenance - support management and operation - production management, in order to keep the system up and running. The living system's theory also reveals those important subsystems found inside the system, influencing its behaviour and growth.

3. ORGANIZATIONAL LEARNING

According to Senge [15] individual learning does not guarantee organizational learning. However he also argues that without individual learning no organizational learning occurs. Therefore it is essential that an organization supports and facilitates individual learning and knowledge creation. This creates a chain of positive events: learning, applying new skills/knowledge and recognition can increase self-confidence in learning new skills and performing them efficiently [8]. There are different kinds of approaches to organizational learning. Figure 2 presents one approach, called the organization's learning cycle.

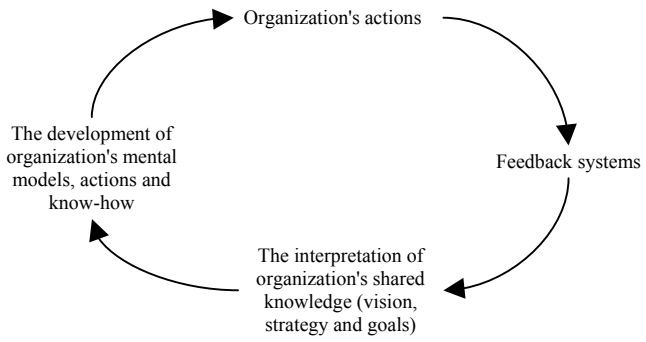

Figure 2: The organization's learning cycle [16].

The starting point of the organization's learning cycle is its present actions [16]. With the help of feedback systems, diverse feedback is systematically gathered. This feedback is then interpreted in order to gain new knowledge and to clarify vision, strategy and goals. It is then possible to develop the organization's mental models, actions and know-how. Sydänmaanlakka [16] also argues that strategic learning, an organization's ability to detect weak signals and its ability to regenerate itself are emphasized in this process. The organization's learning cycle is closely related to the single-loop and double loop learning, cf. [17].

In this paper, we present a co-expert system which can be seen as a part of the organization's learning cycle. The organization's actions and feedback systems depend on the organization's capabilities. The co-expert system can be used to gather knowledge from the people working in the organization; the system interprets this knowledge and produces results according to the given input data. The results suggest those areas where development efforts would be most productive. This knowledge helps in developing the organization's mental models, actions and know-how. In the double-loop learning, information, feedback about the real world not only alters decisions within the context of existing frames and decision rules but also within our mental models [18]. It is therefore possible that the use of the co-expert system could lead to double-loop learning. The system gives information feedback about the real world which can contradict with the dominant mental models of the organization. Consequently development efforts are directed in producing a more responsive environment for future learning and knowledge creation. Thus, the co-expert system does not focus on short term improvements, but instead points out long range development guidelines.

4. ORGANIZATIONAL KNOWLEDGE CREATION

In order to succeed in business competition organizations must have the ability to create new knowledge continuously. Knowledge is an important factor adding value to a firm's products and

services. In our research we have adopted the theory of organizational knowledge creation introduced by Nonaka&Takeuchi [9]. In this theory, knowledge is created in a spiral process where tacit and explicit knowledge interact. This knowledge creation process is based on four different modes of knowledge conversion (SECI process) which are socialization, externalization, combination and internalization (Figure 3).

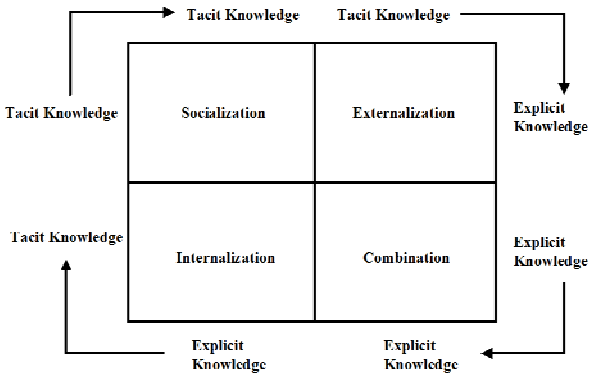

Figure 3: The SECI process [19].

Socialization (from tacit knowledge to tacit knowledge) is a process of sharing experiences; externalization (from tacit knowledge to explicit knowledge) is a process where tacit knowledge is articulated to explicit concepts; combination (from explicit knowledge to explicit knowledge) is a process where concepts are systemized into a knowledge system; internalization is a process where explicit knowledge is embodied into tacit knowledge and is closely related to learning by doing [9]. Malone argues that knowledge management must enable the conversion of knowledge from tacit to explicit, in order to achieve goals set forth [20].

Organizational knowledge creation starts at the individual level and then moves up through communities of interaction crossing sectional, departmental, divisional and organizational boundaries [9]. This spiral process of organizational knowledge creation presents a systemic view on how organizations create new knowledge. It is vital that the organization offers an environment which supports and motivates creative individuals and facilitates interaction between them. Nonaka&Takeuchi [9] describe five conditions which are required in order to promote the knowledge spiral: intention; autonomy; fluctuation and creative chaos; redundancy; requisite variety. If these conditions are not put into practice it is impossible to continuously create new knowledge in a spiral process. The knowledge spiral is the only way to expand individuals' knowledge assets and create new knowledge at an organizational level. A responsive environment comprises those factors which are essential in developing a positive learning environment and support to knowledge-creating activities. In the following section the characteristics of a responsive environment are discussed.

5. THE RESPONSIVE LEARNING AND KNOWLEDGE CREATION ENVIRONMENT

A responsive environment is needed in order to motivate individuals in the process of learning and knowledge creation. In our research we have constructed a responsive environment for learning and knowledge creation, based on certain determining factors. Optimally, according to Ford [7], a responsive environment has the following four functional elements:

1. It must be congruent with an individual's agenda of personal goals.
2. It must be congruent with the person's biological, transactional and cognitive capabilities.
3. It must have the material and informational resources needed to facilitate goal attainment.
4. It must provide an emotional climate that supports and facilitates effective functioning.

A responsive environment must support the phases of the knowledge spiral as discussed in the previous section, yet it must also support organizational learning, and therefore it is essential to identify which conditions occur in a positive learning environment. Tannenbaum [8] has presented eight conditions, which are characteristic of a positive learning environment:

1. Individuals are aware of the big picture, see also [15].
2. Individuals are assigned to tasks where they can apply what they have learned and where they are stretched and challenged, see also [21].
3. Mistakes are tolerated during learning and early application, when individuals are trying new ideas and skills, see also [22;23].
4. Individuals are accountable for learning, and performance expectations are high enough to necessitate continued personal growth, see also [24].
5. Situational constraints on learning and performance are identified and minimized.
6. New ideas are valued and encouraged, see also [25].
7. Supervisors and co-workers provide support allowing individuals to learn and attempt to implement new ideas, see also [21;26].
8. Policies and practices support the effective use of training.

These conditions reflect the learning organization's culture. It can be a time-consuming process to create a responsive environment because it demands a change in the organizational culture. These are slow gradual processes, which can be difficult to detect and follow, cf. [15]. This is why a systemic view is needed in the development process. The *Lituus* computer application can be used to detect and follow these processes.

6. THE *LITUUS* COMPUTER APPLICATION

Lituus is used to gather conscious experiences from the people who are working in the organization. The database contains 97 statements, which are used in the evaluation of an organization's environment in regard to learning and knowledge creation. With the help of these statements people evaluate the current reality and development needs (future vision) of the organization's environment. This way people transfer their own expertise to

the system. As a result *Lituus* gives a meta-classification to the responsive environment for learning and knowledge creation, which connects the theoretical framework to the system's practice, cf. [11]. Table 1 shows how this system level is constructed.

Table 1: Maintaining systems and maintaining systems' features.

Maintaining Systems	Maintaining System's Feature
Control Systems (Command – Control, cf. Samuelson [13])	Leadership
	Human Resource Management
	Management of Technical Issues
	Business Management
	Conversation Management
	Knowledge Management
	Fluctuation and Creative Chaos
	Commitment
	Measuring and Evaluation
Working Systems (Operation – Production, cf. Samuelson [13])	Autonomy
	Team Work
	Rotation of Personnel
	Mentoring
	Continuous Improvement (Kaizen)
Information Systems (Information – Communication, cf. Samuelson [13])	Redundancy
	Requisite Variety
	Human Capital
	Intellectual Assets
	Dissemination of Local Knowledge
	Knowledge Channels
	Knowledge Activists
Support Systems (Maintenance – Support, cf. Samuelson [13])	Organizational Culture
	Dimensions of Care
	Systems of Incentives
	Human Resources Development Policy
	Tools Supporting Learning

As can be seen from Table 1, *Lituus* consists of four different systems: control systems, working systems, information systems and support systems. These systems form the meta-classification for a responsive environment for learning and knowledge creation. There are also 27 features which are divided into four maintaining systems. These features support and facilitate the development of a positive learning environment and knowledge-creating activities. This construction was possible by using fuzzy sets.

Fuzzy sets are a mathematical way of representing vagueness in linguistics [27;28]. Fuzzy systems provide decision support and powerful reasoning capabilities. In general, as the complexity of a system increases, our ability to make precise and yet significant statements about its behaviour diminishes [29]. Fuzzy logic was applied in the *Lituus* co-expert system to cope with imprecise information related to the human decision-making processes and the natural fuzziness related to the evaluations made by individuals.

A general fuzzy logic controller consists of four modules [30]: a fuzzification, inference, rulebase and defuzzification module. *Lituus* contains all these modules and operates through the following phases:

1. The statements describing the organization's environment for learning and knowledge creation are evaluated. All aspects of the learning and knowledge-creating environment are described in linguistic terms. Inputs are then converted into fuzzy sets (fuzzification).
2. Fuzzified inputs are then used by an inference engine to evaluate dynamically created fuzzy rules in rulebase(s). This results in one fuzzy set for each environment's feature (inferencing).
3. Fuzzy sets are then converted into crisp feature values, and furthermore to reports: graphics for individuals and groups, statistical reports for individuals and groups.
4. Fuzzy sets are finally converted into crisp meta-classification values, and again to reports: graphics for individuals and groups, statistical reports for individuals and groups.

A fuzzy logic based co-expert system ‘reveals’ to its users how demanding it is to design or plan a complex object well. The object in this context is the organizational change towards a responsive environment for learning and knowledge creation. Such a decision support system (*Lituus*) identifies those areas where the biggest potential for development exists. It also facilitates the applying of systems thinking in this development process. Figure 4 presents an example of how the use of *Lituus* can lead to reinforcing and balancing feedback processes, cf. [15].

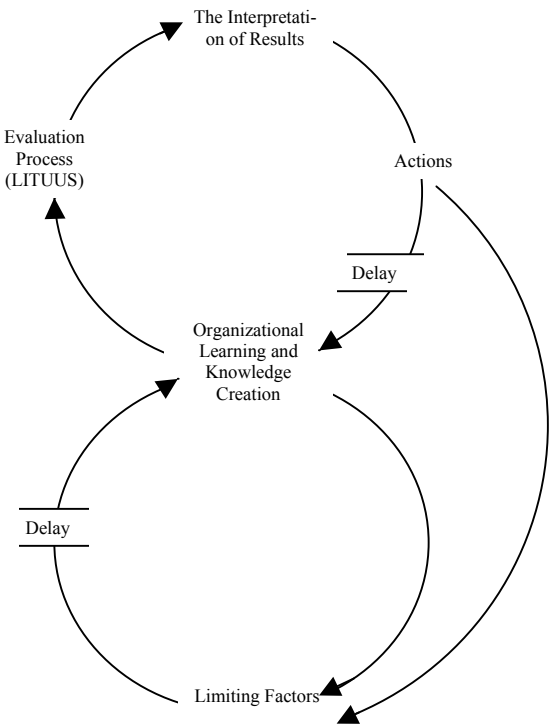

Figure 4: Reinforcing and balancing feedback processes.

As the reinforcing loop in Figure 4 shows, people who are working in the organization use *Lituus* to evaluate their organization from the vantage point of learning and knowledge creation. After these evaluation results are interpreted, actions based on them can be taken. As a result of these development efforts the organization's ability to learn and create new knowledge should improve, however here is a certain delay between actions taken and the achieved improvements. In the balancing loop, the limiting factors affect an organization's ability to learn and create new knowledge. This process also includes a certain delay. The limiting factors can, for example, be a consequence of incorrect interpretation of results.

7. RESEARCH RESULTS

Lituus has already been tested in two case studies. These preliminary tests showed that *Lituus* is capable of showing an organization's development potential of responsive environment for learning and knowledge creation. Figure 5 shows how individuals see the development potential of the 27 maintaining systems' features taken from the *Lituus* report.

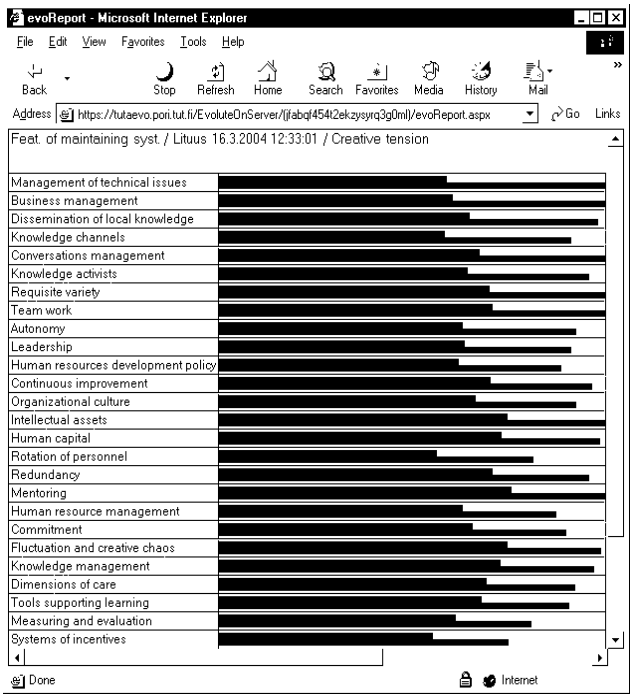

Figure 5: A graphical report describing evaluation results of the maintaining systems' features.

The dark bar in Figure 5 represents the current state, while the light bar (below) represents the developmental needs. The gap between these two represents the development potential. In Figure 5 these features are sorted by the development potential. *Lituus* also forms graphical reports about the system-level, which comprises of four maintaining systems: control systems, information systems, working systems and support systems, Figure 6.

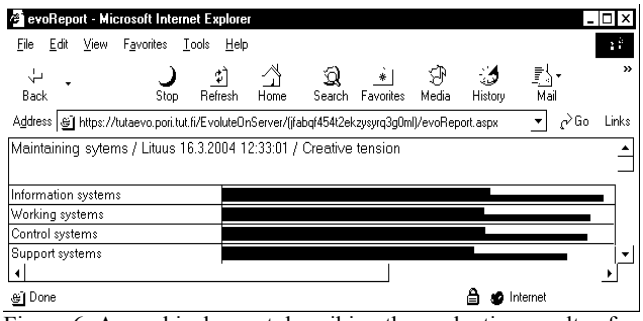

Figure 6: A graphical report describing the evaluation results of the maintaining systems.

This meta-classification (four maintaining systems and 27 maintaining systems' features) helps managers to understand new management issues from the systemic viewpoint. When *Lituus* is used frequently in the organization, it is possible to see how these issues develop over time.

8. CONCLUSIONS

The first preliminary tests have shown that with the help of *Lituus* a systemic view of organization's learning and knowl-

edge creation environment can be formed. *Lituus* forms a meta-classification to the responsive environment for learning and knowledge creation. *Lituus* can point out those areas where organization should direct its focus on development based on this meta-classification. In the future more empirical results are needed to improve the internal consistency of *Lituus*. We hope that *Lituus* system will be used as a management tool that-provides a systemic approach to the management of learning and knowledge-creating organizations.

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