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Managing and Leading Organizational Learning and Knowledge Creation

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ABSTRACT

The ability to learn and create new knowledge is an essential factor in creating an innovative working environment. However, concepts related to learning and knowledge creation are often very abstract in nature. Therefore, understanding and managing these concepts can be very difficult. The processes of learning and knowledge creation require clear specifications, designs, and constructs, so that they are understood similarly among the members of an organization.

The objective of this research is to develop a system to support collective change management and leadership from the viewpoint of learning and knowledge creation. With the help of this system it is possible to understand the concepts related to learning and knowledge creation better, open a dialogue between members of the organization, have a collective view of the organization's current state and target state regarding learning and knowledge creation, plan development activities and follow up the progress. The system also combines issues related to management and leadership.

In this thesis, three ontologies are presented: Lituus - organizational learning and knowledge creation, Talbot - the organization's learning environment and Folium - the organization's new knowledge creation. In addition, a responsive environment for learning and knowledge creation has been constructed. This new construct describes the main principles to support an organization's development from the management and leadership point of view. The ontologies developed are built on a generic, web-based fuzzy application platform which supports the use of applications on the Internet.

In this research, the conceptual research approach was used to define the concepts, which are included in ontologies for the organization's learning environment and knowledge creation activities. The constructive research approach was used when building the applications. The analytical, systemic and actors approaches were also used in different phases of the research.

The empirical part of the research deals with several case studies conducted in different organizations. The empirical results of the research are presented in the research papers that are enclosed in this thesis. The empirical results of the research indicate that by using these applications it is possible to gain a collective view of an organization's environment for learning and knowledge creation.

Keywords: Ontology, Knowledge Creation, Learning Environment, Co-Evolute Methodology

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This research started in 2003 while I was working as a research assistant at Tampere University of Technology Pori unit, Finland. The first research results were presented in the same year as my Master of Science thesis. The second milestone for this research was in 2006 when my licentiate thesis was published. Now, almost ten years later, this thesis brings together all the phases and main results of the research.

This work would not have been possible without Professor Hannu Vanharanta at the Tampere University of Technology. His support has been vital in different phases of the research. I am also grateful to Professor Jussi Kantola who has supported me in developing the applications for learning and knowledge creation. I would like to thank Researcher Pasi Porkka at the Tampere University of Technology for his help in analysing the research results. I would also like to thank University Lecturer Tapio Salminen at the Tampere University of Technology for his support during this research.

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Pori 18.07.2012

Petri Paajanen

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ABBREVIATIONS

HR	Human resources
SSM	Soft Systems Methodology
KBS	Knowledge Based System
MO	Management Object
MOO	Management Object Ontology
SOM	Self-Organizing Map

DEFINITIONS

Tacit knowledge	Knowledge which is related to the experience accumulated by individuals through doing. Tacit knowledge is of a personal nature and is tied to its content. Tacit knowledge is not documented, and for this reason it is difficult to transfer and communicate to others. (Nonaka & Takeuchi 1995; Choo 1998; Sydänmaanlakka 2001)
Explicit knowledge	Knowledge which can be transferred with formal and systematic language. Explicit knowledge can be in the form of symbols, numbers, formulas, documents, and models. (Nonaka & Takeuchi 1995)
SECI process	The organization creates knowledge as a result of the interaction between explicit and tacit knowledge. This interaction is called the knowledge conversion process (SECI process). The four modes of knowledge conversion are S=socialization, E=externalization, C=combination, and I=internalization. (Nonaka et al. 2001b)
Ba	Knowledge needs a physical context to enable the creation of knowledge. Ba is the kind of context where knowledge is shared, created and utilized. Ba provides energy, quality, and a place for the conversations of individuals. (Nonaka et al. 2001b)
Creative tension	Creative tension is the difference between one's personal vision and current state. Creative tension is the force that aims to bring the current state closer to the vision. (Senge 1990)
Proactive vision	Same as creative tension when applied to organizational processes. Proactive vision describes the tension related to the organization's development.
Ontology	The word ontology originates from philosophy, where it means a systematic explanation of being. (Corcho et al. 2003)
Management	These are the targets of management. Organizational

Objects	resources can be considered as a bundle of Management Objects. They include physical objects, mental objects, constructs, and abstract objects (concepts) that are being managed and developed by the management of an organization. (Kantola 2005)
Management Object Ontology	A management object (concept) that is constructed (explicitly specified) as an ontology. (Kantola 2005)
Co-Evolute methodology	The Co-Evolute methodology is based on systems science and presents a co-evolutionary management principle. This principle emphasises the need for a fundamental understanding of the natural processes of the co-evolving of individuals and the organizations in which they work. (Kantola et al. 2006a)
Evo model	The Evo model is used in software development projects. In the Evo model, the first project builds a core system that is further developed in subsequent projects. The Evo model includes a series of repeated cascades, each of which results in a system expanded with new features. (Haikala & Merijärvi 2002; Gilb 1998)

1. INTRODUCTION

Organizations and companies today are part of the knowledge society and have to cope with the challenges of the global world. In order to understand this paradigm shift to the knowledge society it is necessary to make an equivalent paradigmatic shift in the way we think about knowledge and its management (Nonaka et al. 2008, pp. 1-2). Customer needs and expectations regarding products and services are changing rapidly. New knowledge creation allows the firm to respond as quickly as possible to the business requirements of the near and more distant future (Erden et al. 2008, p. 4).

Developments in information technology have also changed the way of communicating with customers. By using the Internet, customers expect that all services should be available regardless of time and place. Customers can even participate in companies' product development processes by using on-line services. Today, social media has also become an important marketing channel for companies' products. The social media is a big opportunity for companies, but it may also have a negative impact. Customers' experiences of using a product or service, whether good or bad, spread rapidly on the Internet. This necessitates a very fast response from the company in order to correct wrong messages and redirect attention to the positive aspects of the product or service. Operating environment can be seen as a moving target where companies are trying to modify their operations (Nonaka & Toyama 2003, p. 4). Faced with these challenges, companies' activities are today characterized by innovativeness, speed and proactivity rather than fixed practices.

In addition to the changes that have taken place in the business environment, work itself has also changed towards knowledge work. Nowadays people are well educated and this new generation is accustomed to working in networks with supervisors, managers and customers. Key motivators for people are clear and understandable objectives, the opportunity to learn new things, an inspiring and innovative working environment and the authority to make decisions by themselves. Companies and organizations are becoming more network-based, where added value is created for the customers with the help of partners. Networks can be seen as the place where the processes of learning and knowledge sedimentation take place (Corno et al. 1999, p. 381). Thus managing the ability to learn and create new knowledge has become a part of a company's everyday activities. Therefore, there is also a need to change the way companies and organizations are managed.

The traditional approach to management, which has been based on the fact that the strategy work and decision-making takes place only at the top level of the organization, no longer works in innovative and network-based organizations where learning and knowledge creation are key issues. In traditional organization theory, an organization is viewed as an information-processing machine that takes and processes information from the environment to solve a problem and adapts to the environment based on a given goal (Nonaka & Toyama 2003, p. 3). In order to maintain competitive advantage, a firm's investment decisions related to knowledge creation are likely to be strategic in nature (Chen & Edgington 2005, p. 279). The worst case is where only the management team creates the strategy and then it slowly filters down (if ever) to the other levels of the company. In this case strategy might be only one paper among many others and it is never discussed how the strategy affects employees' everyday work. In this case management lacks a comprehensive and collective view of the organization's current state of activities and future challenges. It is possible that even major problem points or inefficiency of functions are not known by the management and therefore development of activities is based on assumptions rather than on real knowledge.

People participating in the strategy process try to predict the future state of their organization. The goal of the strategy process is the transition from the current state to the future state. It is important that people in the organization have a shared vision as the basis for development. The strategy process can become complex and problematic if members of the organization lack a shared understanding of the future state of the organization and a common view of its operating environment. (Kantola & Vanharanta 2012)

The issues presented above raise major challenges for managing today's organizations. The ability to learn and create new knowledge is an essential factor in creating an innovative working environment. It has been stated that while knowledge creation is fundamental to the survival of a business, it has not been extensively researched beyond organizational theory (Chen & Edgington 2005, p. 280). Concepts of learning and knowledge creation are often very abstract and fuzzy in nature. This also brings challenges to communication with personnel if the concept in hand is complex and hard to perceive. Therefore, understanding and managing these issues can be difficult. Nonaka and Takeuchi (1995) have for example identified four different modes of knowledge conversion (the SECI process), which are socialization, externalization, combination, and internalization. Managing these issues raises questions in organizations: how to get the entire organization's collective view of these issues, how to develop them, and how to follow up the impact of development activities? The processes of learning and knowledge creation require clear

specifications, designs, and constructs, so that they are understood similarly. This research began on the basis of these challenges.

This thesis presents a new management and leadership methodology, which can be used for strategic management purposes to manage change and to lead the company resources efficiently and effectively towards a new future from the viewpoint of learning and knowledge creation. The research method is based on management and leadership ontologies, which can be used to capture the current and future views of personnel to be used for managing and leading organizational learning and knowledge creation. In this research, three ontologies are presented: Lituus - organizational learning and knowledge creation, Talbot - an organization's learning environment and Folium - an organization's new knowledge creation. These ontologies are built on a generic web-based fuzzy application platform which supports the use of applications on the Internet. These applications enable the attainment of a collective view of the organization's current state and target state regarding learning and knowledge creation. Applications include linguistic statements, which describe organizational features from the viewpoint of learning and knowledge creation. In each statement people are asked to evaluate the current state and target state (future vision) of each feature. As a result of the evaluation, it is possible to visualize the proactive vision, which is the gap between target state and the current reality.

In the first phase of the research, the Lituus application was developed. Lituus can be used to map the collective view of the organization's environment from the viewpoint of learning and knowledge creation. The research was continued, because the view of learning and knowledge creation processes was not at an adequate level. It was therefore concluded that separate applications were needed for the learning environment and knowledge creation activities. In the second phase of the research two applications were developed: the Talbot application to study the organization's learning environment and the Folium application to study its knowledge creation activities.

These applications enable managers to evaluate the current reality and target state of the organization's activities by using the "bottom-up - top-down" principle. By using these applications it is possible to open a dialogue between members of the organization. When this dialogue is started, people who work in the organization can take part in the development work and be more committed to the required change. This enables the use of collective change management and leadership in the organizational development work. By using these applications it is possible to develop the organization based on the collective view and fact-based knowledge. These applications also make it possible to

study concepts related to the organization's maintaining systems by producing meta-knowledge.

With the help of the applications presented in this research, the aim is to manage the dynamic changes that take place in an organization's environment and to respond to the challenges caused by these changes. Applications are used as decision support systems to identify development needs, set goals for development and follow up the organization's development. The essential goal of using these applications is to enable fact-based management of the organization's learning environment and knowledge creation activities.

1.1. Background

Several measurement instruments to assess and analyse learning organizations have already been developed. Below are listed eight different measurement tools for the assessment of learning organizations based on the work of Moilanen (2001, pp. 212-214) and Jamali et al. (2009, pp.106-108):

1. Pedler et al. (1988, 1989) developed the Learning Company Questionnaire, which is based on eleven dimensions, each of which is described by statements. These dimensions concentrate on issues related to strategy, factors internal to the company, and learning opportunities. This measurement tool has been used in a research study conducted in several British companies. The main focus of the tool is the role of the individual in the context of the whole organization.
2. The Complete Learning Organization Benchmark developed by Mayo and Lank (1994), including nine different sub-areas and 187 questions. The measurement tool emphasizes the factors needed in the development of a learning organization.
3. The measurement tool developed by Tannenbaum (1997) with the main emphasis on learning environments. The tool concentrates on existing processes, training related issues, and work-related learning. Tannenbaum's tool can help managers in fostering and encouraging learning in organizations.
4. Pearn et al. (1995) introduced the Learning Audit, which is comprehensive from the viewpoint of the supervision and support of learning, but relatively superficial in terms of supporting the entire learning organization. This tool is based on a questionnaire consisting of five parts, which studies the role of the organization as a whole, the individual's specific role and the role of the HR function in leading and encouraging learning.

5. The measurement instrument, Recognizing Your Organization, developed by Sarala and Sarala (1996, 1998), classifies organizations of different types and does not directly measure the different sub-areas of learning organizations. The main focus of the tool is to identify whether an organization qualifies as a learning organization. In this tool, a learning organization is one of the five organizational types in their classification.
6. The Learning Organization Test developed by Otala (1996) is a general test consisting of twenty statements. The brevity of the test is one reason that makes it difficult to use when a truly comprehensive picture of learning organizations is required.
7. Redding and Catalanello (1997) presented the Learning Organization Capability Assessment, which aims to differentiate learning organizations from other organizations. Their tool defines three archetypes of organizations: traditional, continuously improving, and learning organizations. However, this instrument too is unable to examine learning organizations in more depth.
8. The Dimensions of the Learning Organization Questionnaire was developed by Watkins and Marsick (1998). This questionnaire is organized into five sections that assess individual-level, team-level, and organization-level learning, and also measure the financial performance of the organization. The last section of the questionnaire is used to gather information about the organization and the role of the respondents in the organization. Thus, the tool gives a fairly comprehensive picture of the attributes of learning organizations.

Garwin et al. (2008) have introduced an assessment tool, which can be used to pinpoint areas where companies need to foster knowledge sharing, idea development, learning from mistakes and holistic thinking. Their tool measures the learning that occurs in an organizational unit of any size that has meaningful shared or overlapping work activities. The tool comprises of three blocks (Garwin et al. 2008, pp. 111-113):

- Building block 1: *A supportive learning environment* contains four distinguishing characteristics which are psychological safety, appreciation of differences, openness to new ideas and time for reflection.
- Building block 2: *Concrete learning processes and practices* involve the generation, collection, interpretation and dissemination of information. This block includes four characteristics, which are experimentation, information collection, education and training, and information transfer.

- Building block 3: *Leadership that reinforces learning* assesses how the behaviour of leaders influences organizational learning. Garwin et al. state that "when people in power demonstrate through their own behaviour a willingness to entertain alternative points of view, employees feel emboldened to offer new ideas and options".

Garwin et al. refer to these as the building blocks of the learning organization. The tool includes self-assessment statements, which are divided into three sections. Each section represents one building block of the learning organization. In the first two blocks, the user's task is to rate, on a seven-point scale, how accurately each statement describes the organizational unit where the user works. In the third block, the user's task is to rate how often the managers exemplify the behaviour described. (Garwin et al. 2008, p. 110, 112)

Chen and Edgington have developed a model based on economic and organization theory for assessing organizational value with regard to knowledge creation investments. Their model considers a number of decision criteria pertinent to the organizational value of formal and structured knowledge creation. The model is broken down into a number of complex variables and addresses the dynamic nature of organizational knowledge creation and depreciation. The model quantifies the decision criteria required by managers and knowledge workers with regard to knowledge creation process investment decisions. (Chen & Edgington 2005)

Song et al. have introduced a systematic scale for measuring organizational knowledge creation practices, based on the SECI process of the knowledge creation theory. The development process of the scale included initial item and domain development based on a comprehensive literature review, reliability assessment and item deduction, and construct validity and psychometric property assessment. (Song et al. 2011, pp. 243-244)

First, based on the literature review, 26 measurement items were constructed for the SECI process. Based on feedback and comments from a panel of experts, some items were merged. As a result, a total of 23 proposed items were included in the data analysis, which used a Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Data were collected from a sample of 455 knowledge workers from four Korean for-profit organizations. As a result, 17 items related to individual and team members' practices of acquiring and sharing knowledge in organizational contexts measured the four domains of the SECI knowledge creation practice. The research also studied the correlations between the modes of the SECI process. According to Song et al., their

research is the first statistically comprehensive attempt to develop scales of organizational knowledge creation practices. (Song et al. 2011)

Most of the previously developed measurement tools for organizational learning and knowledge creation often focus on analysis of the organization's current state. These tools do not map out the organization's members' views on what areas in particular should be developed in the future. From the management point of view, previously developed measurement tools do not directly point out activities and tools, which can be used to manage and develop different areas related to learning and knowledge creation. This research presents assessment systems, which are different from most of the previously developed measurement tools due to the fact that they examine the organization's current state as well as the target state based on the views of the members of the organization. This makes it possible to examine the gap between the current state and target state. This difference describes the tension related to the organization's development (cf. Senge 1990).

When previously developed measurement tools were reviewed during the research, the analysis did not reveal any tool that could produce management related meta-knowledge as a result of the assessment. The assessment systems presented in this research include a meta-level. This level is capable of pointing out issues and tools, which can be used to mobilize the organization's development work in relation to learning and knowledge creation. Therefore, the assessment systems presented in this research introduce a completely new type of approach to measuring an organization's learning and knowledge creation.

1.2. Problem formulation and research objectives

The objective of this research is to develop an assessment system to support collective change management and leadership from the viewpoint of learning and knowledge creation. With the help of this system it is possible to understand better concepts related to learning and knowledge creation, open a dialogue between members of the organization, gain a collective view of the organization's current state and target state regarding learning and knowledge creation, plan development activities and follow up the progress. The system also combines issues related to management and leadership. Figure 1 summarizes the challenges of this research.

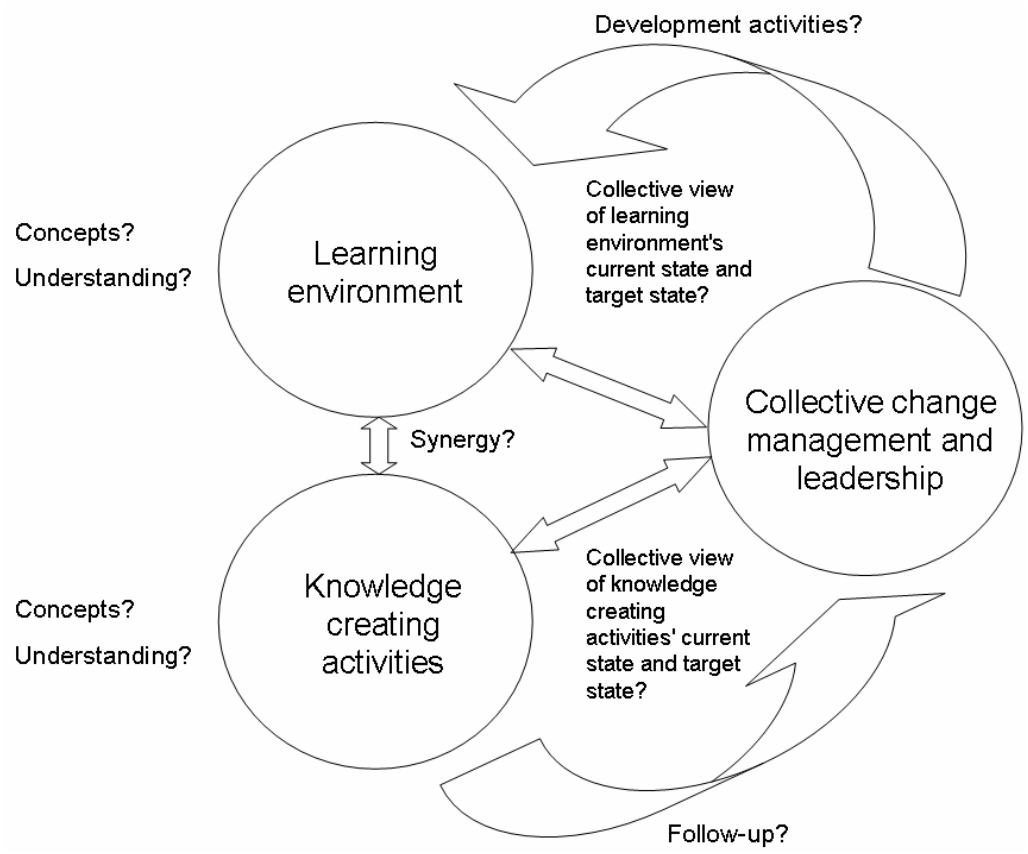

Figure 1. Challenges of the research.

The objective of the research can be divided into the following sub-goals:

The first sub-goal of this research is to explore the theories related to the research topic and to create a theoretical framework for the research. In the theoretical framework, the central theories are studied that define the content of ontologies related to the organization's learning environment and knowledge creation.

The second sub-goal is to construct ontologies for the learning environment and knowledge creation and to include these in Co-Evolute methodology (Vanharanta 2005). In this phase the statements, features, and classes of applications are also defined.

The third sub-goal is to include the developed ontologies in a generic web-based fuzzy application platform, which supports the use of applications on the Internet.

The fourth sub-goal is to test the applications in different case studies. These case studies enable an assessment of how the developed applications can support collective change management and leadership in practice.

This research is limited to reviewing organizations only from the viewpoint of learning and knowledge creation. The research aims to develop generic applications, which can help different kinds of organizations to make development plans related to learning and knowledge creation.

1.3. Research strategy

Figure 2 presents the research process onion, which describes research philosophies, research approaches and research strategies. This research is hermeneutic, because non-quantitative data is used to study the research object, which is in this case the organization's learning environment and knowledge creation activities.

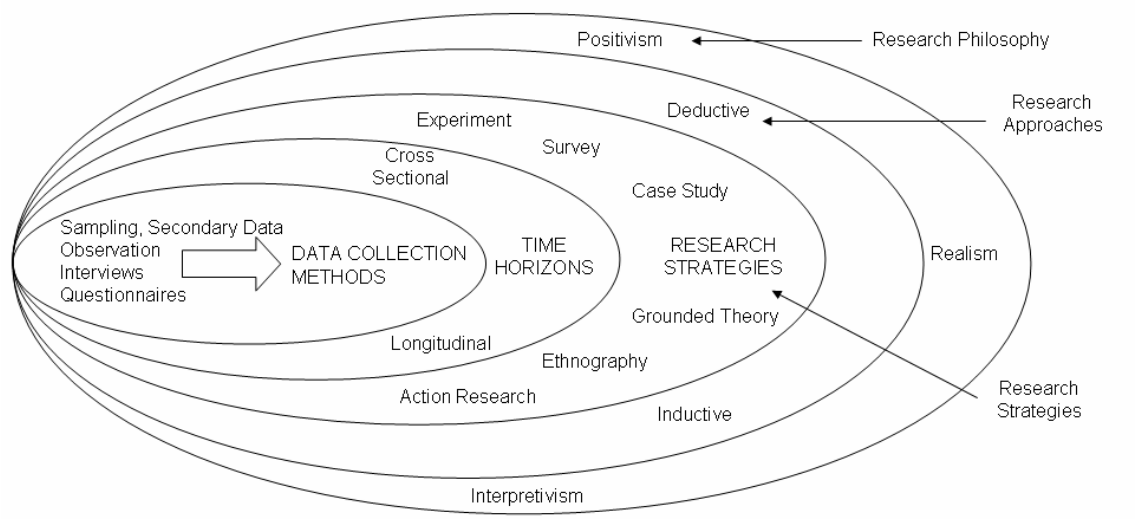

Figure 2. The research process onion (Saunders et al. 2003).

This research belongs to the field of industrial engineering and management. Olkkonen states that Eero Eloranta's definition concerning the field of industrial engineering and management fits all business economics well. According to this definition, industrial engineering and management belongs particularly to the design sciences. The tendency for epistemic and practical benefit at the same time is characteristic of design sciences. The contribution of research done in the field of industrial engineering and management should be new knowledge for the scientific community and knowledge containing practical benefit for business life. Research in the field of industrial engineering and management often seeks to answer the question of what the world should be. It also emphasizes the relevance of the research problem rather than the methods. As a result, various approaches, research methods and explaining mechanisms are used in different research themes. (Olkkonen 1994, p. 59)

The most typical research approaches in business economics can be linked to positivism or hermeneutics. According to positivistic research philosophy, acquisition of knowledge is only based on identified and verified observations. These observations are only processed with methods which are independent of the researcher's own interpretations. On the contrary, in hermeneutic research philosophy, acquisition of knowledge includes the understanding of people who are working with the researcher and phenomenon under study. Processing of observations is based on the researcher's interpretation. In research work, it is rare to find a research that would be purely either positivistic or hermeneutic. There are a few typical research approaches in business economics which combine these two philosophies. Examples of these are the conceptual approach and constructive approach. (Olkkonen 1994, pp. 50-53, 59)

In Finland, the basic grouping of research approaches is based on a division into conceptual, nomothetical, decision-oriented and action-oriented approaches, as defined by Neilimo and Näsi (1980). Kasanen et al. (1991) have later added the constructive approach to this grouping. This research approach is placed close to the decision-oriented and action-oriented approaches. Grouping is based on the use of knowledge (descriptive / normative) and on the method how knowledge is acquired (theoretical / empirical). Figure 3 presents how these research approaches are divided into four sections.

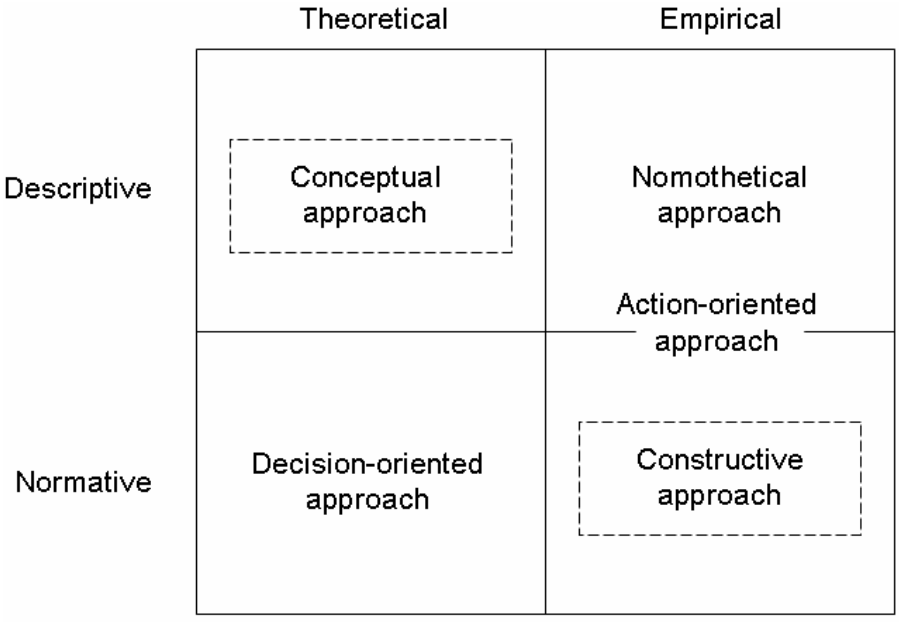

Figure 3. Four sections of research approaches (adapted from Kasanen et al. 1991, p. 302)

In this research, both the conceptual and constructive research approaches are used. The purpose of the conceptual research approach is to develop conceptual systems, which are needed for example to describe and identify

phenomena, to make a typology, to organize knowledge and form a basis for design systems. The concept developed may be entirely new or a more developed form of a known concept. The justification of a concept, which is a result of the conceptual research approach, is usually done through testing. The purpose of testing is to demonstrate the functionality of a concept and its superiority compared to earlier concepts. (Olkkonen 1994, pp. 65-66)

In this research the conceptual research approach is used to define the concepts, which are included in ontologies for an organization's learning environment and knowledge creation activities. Testing of the developed concepts is carried out in case studies.

Olkkonen has noted that Kasanen, Lukka and Siitonen characterize constructive research as normative research, which aims at problem solving. Constructive research combines goal-oriented and innovative processing of a problem, empirical testing of the solution's functionality on a practical level and a review of the scope of application. Therefore, the constructive approach is close to the decision-oriented approach and the action-oriented approach. (Olkkonen 1994, p. 76) Figure 4 presents the research process when the constructive research approach is being used in this research.

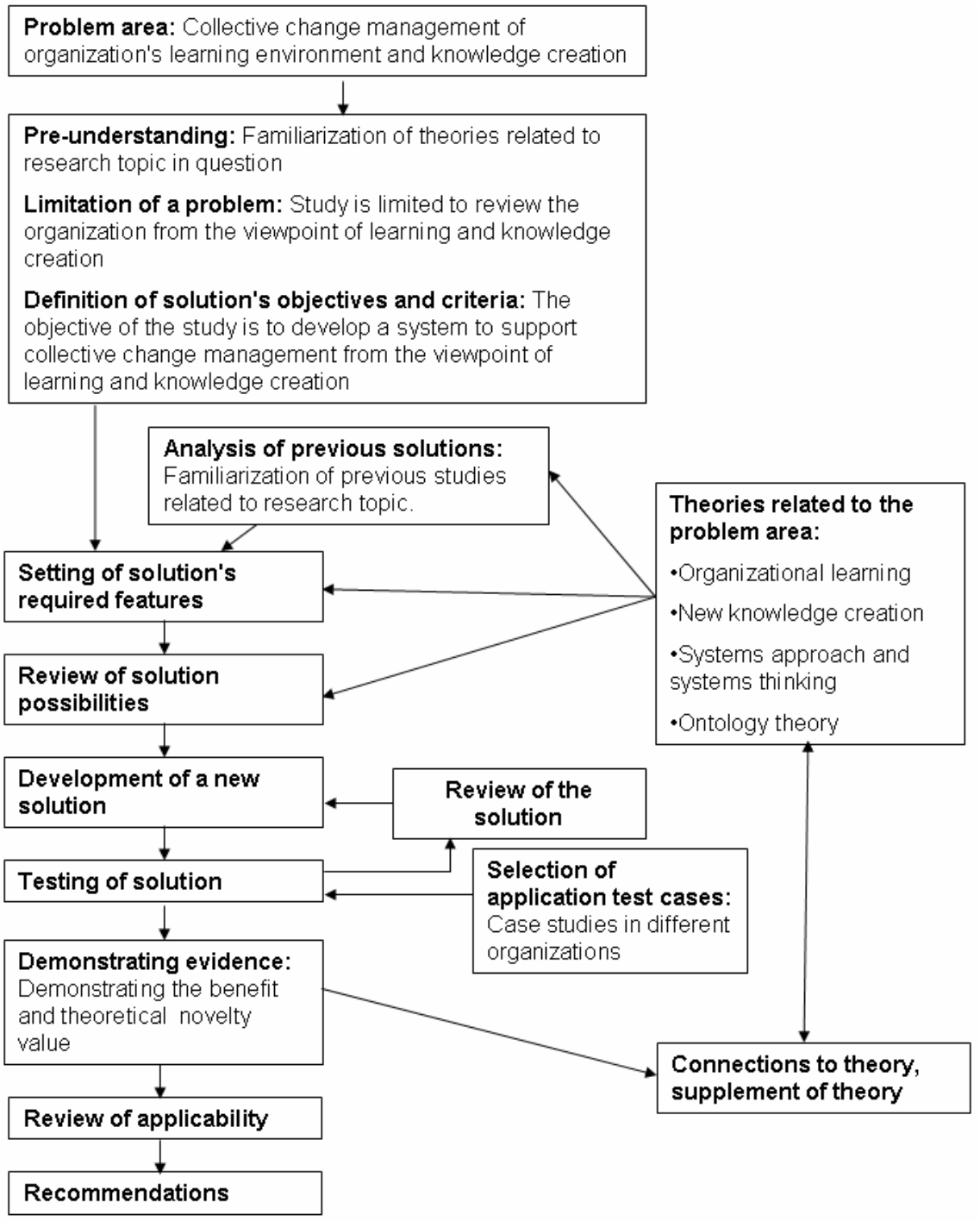

Figure 4. Basic structure of constructive research (adapted from Olkkonen 1994, p. 79).

The constructive research approach is used when building assessment systems for an organization's learning environment and knowledge creation activities. It is assumed that the developed constructs have the possibility to influence the development of an organization's operating environment for learning and knowledge creation in a more responsive direction. Different case studies are used to find out how the constructs work in practice. Based on the evaluation of

the research results it is possible to assess how the old theories are supported and what is the utility and novelty value of the research.

According to Arbnor and Bjerke (1997, p. 49) there are three methodological approaches operating in business research today: the analytical approach, the systems approach, and the actors approach.

The analytical approach is the oldest of the three and has its origin in classic analytical philosophy. In the analytical approach it is assumed that reality has a summative character. This means that the whole can be seen as the sum of its parts. The knowledge created by using the analytical approach is independent of the observer. Arbnor and Bjerke state that the goal of the analytical approach is to explain objective reality as fully as possible. Causal relations are used in the explanations. (Arbnor & Bjerke 1997, pp. 49-50, 60)

In contrast to the analytical approach, the assumption behind the systems approach is that reality is arranged in such a way that the whole differs from the sum of its parts. In the systems approach, the relationships of the parts are important. Systems reality consists of components which are dependent on each other and cannot be summed up. Therefore it is not possible to remove any of the components without the risk of affecting the total picture. According to Arbnor and Bjerke, the behaviour of individuals also follows systems principles. Therefore the systems approach can be used to explain individuals in terms of systems characteristics. (Arbnor & Bjerke 1997, pp. 51-52, 65)

The actors approach is used to understand social wholes. According to Arbnor and Bjerke, this is accomplished through the pictures of reality held by individual actors in a particular social context. In the actors approach reality is seen as a social construction that is intentionally created by processes at different levels of meaning structures. In contrast to the analytical approach, the reality is not independent of its observers. The actors approach also differs from the systems approach, because in the former systems characteristics are not relevant to the understanding of businesses and organizations. Arbnor and Bjerke state that knowledge developed with the actors approach is dependent on the actors. In the actors approach, objectivity is created by people and can be questioned and changed. (Arbnor & Bjerke 1997, p. 52, 71)

In this research all three of the methodological approaches presented above are used in different phases of the research. The analytical approach is used when studying general views of an organization's learning environment and knowledge creation activities based on different concepts. The systems approach is used when constructing a responsive environment for learning and

knowledge creation. This framework consists of four maintaining systems and 26 maintaining systems' features. The meta-knowledge level of the Lituus, Talbot and Folium applications is based on this framework. Meta-knowledge can be used to promote an organization's ability to learn and create new knowledge in a systematic way. The actors approach is applied when interpreting the results of the case studies. Based on these results it is possible to study how members of the organization view their organization from the viewpoint of learning and knowledge creation.

1.4. Contents of thesis

The contents of this thesis are presented in Figure 5. The thesis consists of five chapters and six research papers as the appendix. Chapter 2 comprises the theoretical framework of the thesis. Chapter 3 presents the construction of the applications developed for learning and knowledge creation. This chapter presents the results of the theoretical research. Chapter 4 presents the summaries of research papers and the latest research. This chapter presents the results of the empirical research. Research papers are used to show how the research and development of the applications proceeded. The results of the case studies are also presented in the research papers.

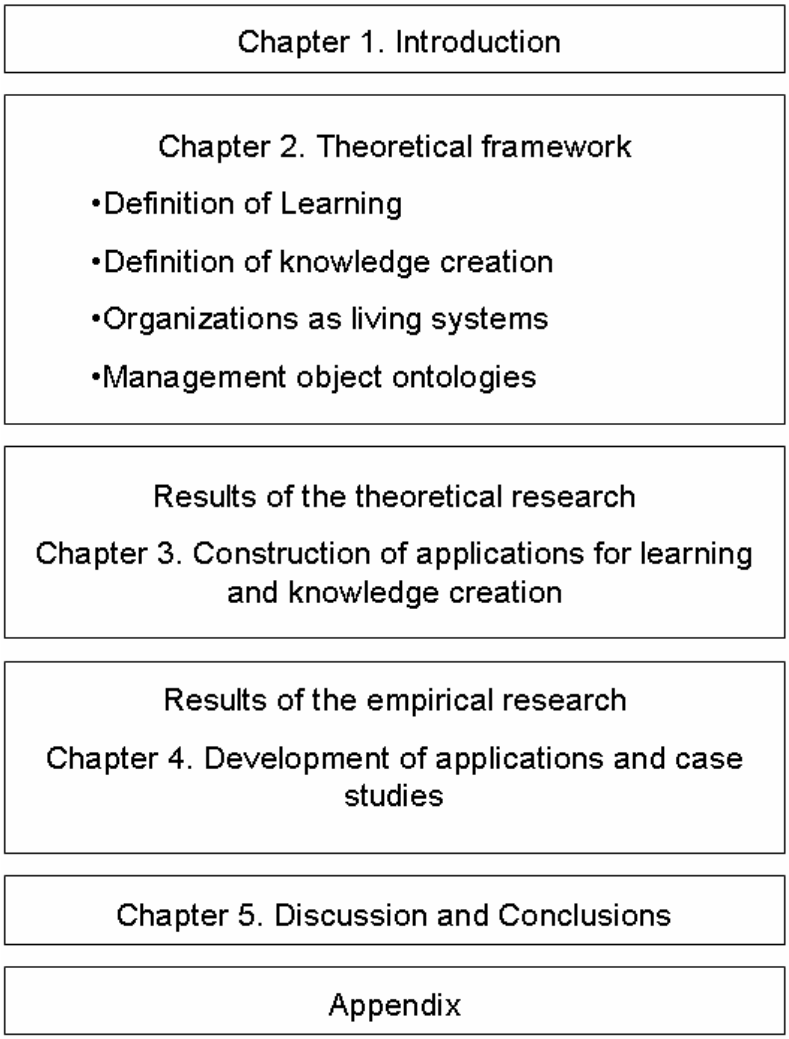

Figure 5. Contents of the thesis.

Chapter 1 comprises an introduction to the research. At the beginning of the introduction different perspectives are brought out, which define the need and timeliness of the research. The chapter also deals with problem formulation, background of the research, objectives, limitations and research strategy. The contents of the thesis are also presented in Chapter 1.

Chapter 2 deals with the theoretical framework of the research on which the development work on applications for organizations' learning environment and knowledge creation is based. In this research, organizations are seen as comprehensive systems, which have the ability to change and evolve. Chapter 2 studies concepts related to learning, learning organization, barriers to learning, new knowledge creation, systems approach and ontologies. Learning is studied at the levels of the individual, group and organization. New knowledge creation is studied based on Nonaka and Takeuchi's (1995) knowledge spiral. This knowledge spiral describes the interaction between explicit and tacit knowledge in the new knowledge creation process. In Chapter

2 a responsive environment for learning and knowledge creation is presented based on the systems approach. The review of ontologies is based on the theory related to the definition and construction of ontologies. In this research, learning environment and knowledge creation are seen as management objects, which can be defined with the help of ontologies and managed in a holistic way.

Chapter 3 presents the results of the theoretical research. This chapter presents applications for evaluating an organization's learning environment and knowledge creation. At the beginning of the chapter, the Lituus application is briefly presented. Lituus can be used in the evaluation of an organization's learning environment and knowledge creation. The development work for Lituus was the starting point for this research. As the research proceeded, two separate applications were developed: Talbot for the organization's learning environment and Folium for the organization's knowledge creation activities. Chapter 3 presents the structure and operating principles of these three applications.

Chapter 4 presents a summary of the research papers. These research papers illustrate the different phases of this research. The research papers deal with different case studies and methods for reviewing the evaluation results. This chapter also presents the results of the latest research. The Talbot and Folium ontologies are used as a basis for the Serpentine ontology, which defines features of safety culture. This chapter presents the results from a safety culture assessment carried out in companies belonging to the industrial sector and the energy sector. Chapter 4 presents the main results of the empirical research.

Chapter 5 examines how well the research objective was realized and how the chosen research approaches were suitable for this research. It also examines the theoretical contribution of the research and topics for further research.

Appendix. Six research papers are attached to this thesis. The author's contribution in each publication is also presented.

2. THEORETICAL FRAMEWORK

In this research the focus is on finding out how to boost and support the individuals', teams' and organization's ability to learn and create new knowledge in the daily working environment. In this chapter, learning and knowledge creation are studied on the basis of a literature review.

2.1. Definition of learning

Firms need to develop their learning capability in order to achieve competitive advantage (Pérez López et al. 2002, p. 120). According to Huysman (2000, p. 83), learning is valuable from the managerial perspective since it helps organizations to increase their efficiency and competitiveness. Learning includes the relationship between available knowledge and potential behaviour. From the process point of view, learning can be seen as a dynamic process that connects past, present and future knowledge. (Martín de Castro et al. 2010, p. 5)

According to Nevis et. al. (2000, p. 44), learning is also a systems-level phenomenon because it stays within the organization, even if individuals change. Nevis et al. have studied successful firms and their research has identified three learning-related factors which are important for their success (Nevis et al. 2000, p. 44):

1. Well-developed core competences that serve as launch points for new products and services.
2. An attitude that supports continuous improvement in the business's value-added chain.
3. The ability to renew or revitalize fundamentally.

Learning can occur on the level of individual, team or organization. This means that learning can also be supported on each of these levels. Individuals create opportunities for continuous learning by purposefully questioning and developing their own activity. Teams, in turn, make it possible to learn together and to share learning. Organizations authorize and issue challenges to both individuals and teams. Organizations are also responsible for creating structures that support learning and for rewarding the development of know-how. (Sydänmaanlakka 2001, p. 45) Thus, the requirement that an organization must learn concerns both the whole organization and its constituent parts. When the organization learns on individual, team and organization levels so that it reaches its goals better than before through the learning process, it can be

seen as a learning organization. (Otala 2000, pp. 167-168) Figure 6 presents the organizational learning process.

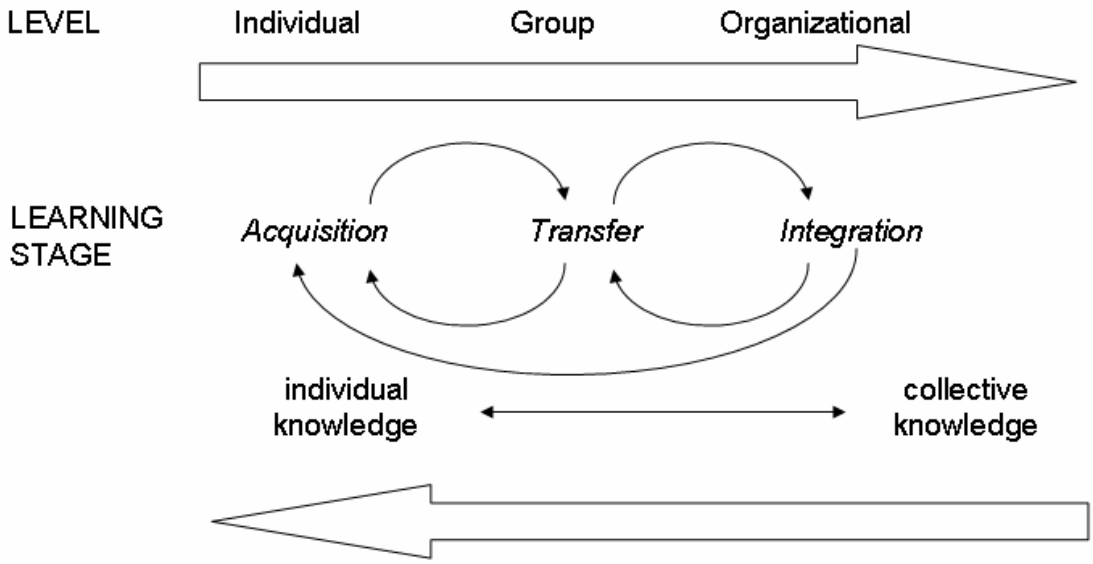

Figure 6. Organizational learning process (Jerez-Gómez et al. 2005, p. 716).

As can be seen from Figure 6, as a result of learning, individual knowledge will become collective knowledge. Organized learning is a collective phenomenon. Collective knowledge is important for the organization because it will become the main foundation of the organization, of its growth, and its rent-generation strategy. Organizational structure is also one of the most important elements because it specifies interactions between individuals and groups within an organization. (Pérez López et al. 2002, p. 119, 121, 127) From the management point of view, learning and professional development also need the top-level support of teams and individuals (Mulholland et al. 2005, p. 128).

2.1.1. Individual learning

As learning always happens first on the individual level, all learning has as its starting point the learning of individuals. Learning is a process where an individual acquires knowledge, skills, attitudes, experiences and contacts that lead to changes in the individual's activity. (Sydänmaanlakka 2001, p. 47) Von Krogh (2009, p. 122) states that learning by individuals occurs when they assume and adjust to the roles that constitute the organization. Learning should be seen as a skill that can be developed. The skill of learning consists of different elements, including attitudes to learning, systematicity, learning techniques, general talent and the individual's earlier knowledge of the matter to be learned. (Sydänmaanlakka 2001, p. 47)

According to Ruohotie, learning strategies are used to aid the acquisition, handling, memorization and recall of knowledge. The strategy chosen by the learner is vitally important for what is learned. Learning strategies are special ways of acting on which the learner relies to make learning easier, quicker, more pleasant, more autonomous, more efficient and easy to move to new situations. (Ruohotie 2000, pp. 95-96)

Sydänmaanlakka has noted that Honey and Mumford divided people by learning style into four different types: active participant, cautious observer, logical thinker, and practical realizer. Of these, practical realizers learn best by doing; on the other hand, learning by theoretical exercises is hard for them. Cautious observers learn best when they can gather new knowledge in peace and assess it. Cautious observers like to observe things at a distance and analyse the doings of others. Learning must be systematic, which makes it hard for cautious observers to adapt to quick changes. Logical thinkers learn best by building logical models. Logical thinkers want to question, experiment and analyse matters from different angles. They consider it important to internalize things. Active participants learn best by experimenting, receiving challenging tasks, and being involved in many different things. Active participants do not immerse themselves in matters deeply, wanting instead to act at a quick tempo. (Sydänmaanlakka 2001, pp. 38-39)

According to Tannenbaum, continuous learning on an individual level can be seen as a cycle, which is presented in Figure 7. As this cycle shows, individuals participate in essential learning experiences, such as receiving instructions from a colleague or working in a group. These kinds of learning experiences help individuals to develop new competences to be applied at work. It is also essential that the individuals who apply new ideas and skills are noticed and rewarded. In this cycle presenting continuous learning, the individual's motivation to learn is increased by learning, application and recognition. As a consequence, participation in these experiences makes individuals more receptive to learning and more likely to seek out other learning experiences. Figure 7 presents how continuous learning can increase when all the elements are properly aligned, but a disconnection anywhere in the cycle can be detrimental to continuous learning. (Tannenbaum 1997, pp. 438-439)

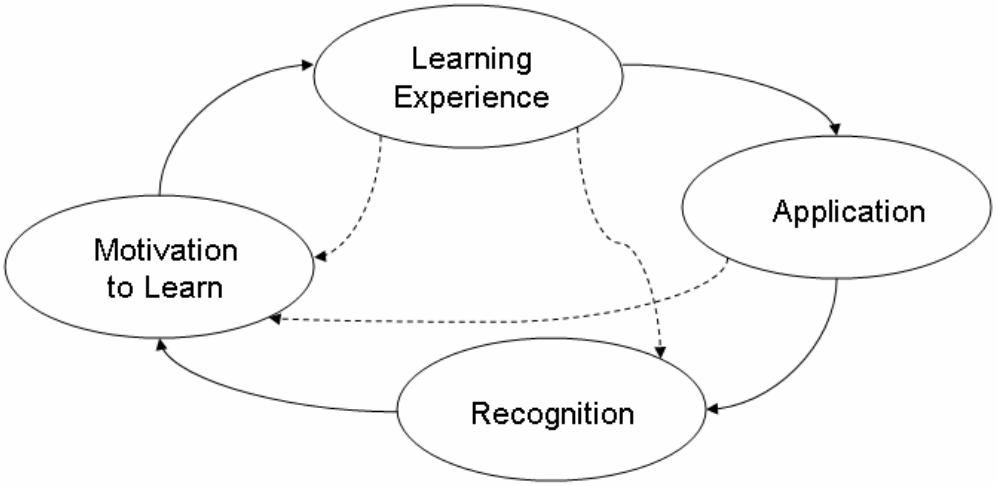

Figure 7. Continuous learning cycle (Tannenbaum 1997, p. 439).

As illustrated in Figure 7, the cycle includes several internal feedback arrows (dotted lines). The dotted line going from learning experience back to learning motivation reflects the fact that for some individuals, the learning experience itself can be motivating. The dotted line going from application to motivation shows how the successful application of new ideas and skills may itself be motivating, regardless of whether the organization notices and rewards the achievement. The last feedback arrow is located between the learning experience and recognition. In some organizations, individuals are rewarded for participation in learning experiences and for the acquisition of new skills regardless of whether these skills can be applied to the individual's work. In connection with this, the idea that the new skills can be applied in the near future is crucial. Rewarding an individual for activity can also be negative if the learning experience is not related in any way to business needs. (Tannenbaum 1997, pp. 438-439)

2.1.2. Team learning

The basic unit of a learning organization is the team, where individuals learn together. Teams cannot learn by themselves. In general, the learning that occurs together in one team is transferred by the members to other teams. Team learning largely follows the same model as organizational learning. However, a team has a more solid bond between the members, and in addition to shared goals, “team spirit” also keeps the team together. The skills of a team are not the sum of its members' skills, and the learning of a team does not mean the development of individual members’ skills. Team learning depends on how well the team is able to combine its members’ learning in order to reach shared goals. (Otala 2000, pp. 183-184) However, team learning is similar to individual learning. It can also be seen as a process where the team acquires new knowledge, skills, experience and contacts that lead to changes in the

team's activity. Team learning can be seen as a learning cycle, as shown in Figure 8. (Sydänmaanlakka 2001, p. 48)

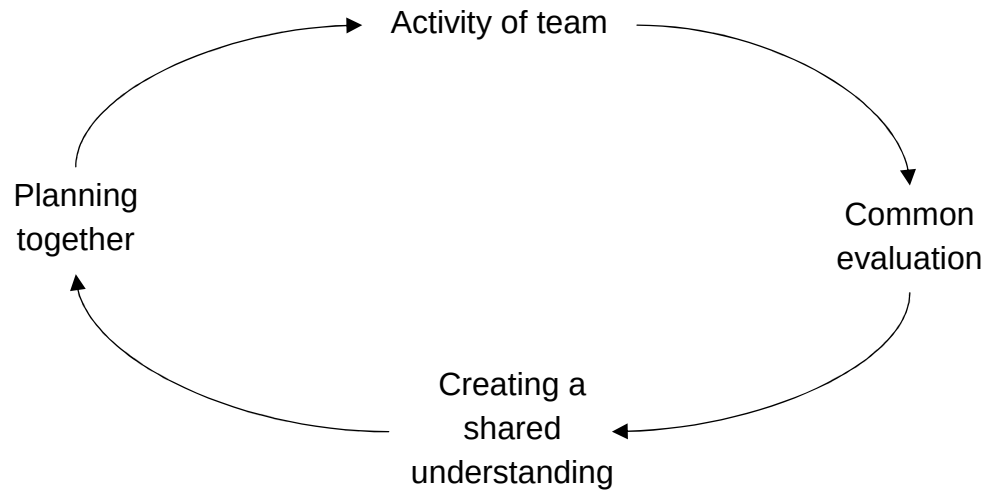

Figure 8. Team's learning cycle (Sydänmaanlakka 2001, p. 48).

According to Sydänmaanlakka, the starting point of the team's cycle of learning is its current activity, which should be reassessed regularly to enable the team to improve its results. On the basis of the reassessment, a shared understanding can be formed of the current situation and of future goals. After this, shared plans are made on how the activity can be developed. Team learning requires shared goals and operational models, shared responsibility and a good team spirit. (Sydänmaanlakka 2001, p. 48) Team spirit creates the basis for the activity and generates synergy in thinking. It is important from the viewpoint of learning, as team spirit also leaves room for different views. It can also be seen that learning requires a shared language by the members, an ability to discuss and communicate, and an ability to handle conflicts. Learning also depends on how well the team members know each other and can share their know-how. (Otala 2000, p. 184)

2.1.3. Organizational learning

The learning of individuals is not the same as the learning of organizations. Although individuals may learn, the organization is not necessarily renewed if the individuals do not learn to act together and combine their learning. (Kauhanen 2000, p. 148) Organizational learning is also more than the sum of individuals' learning. Organizational learning is the ability to combine individuals' learning together in order to reach shared goals. Team learning often functions as a connector of this kind. Organizational learning produces new knowledge in organizations. (Otala 2000, pp. 168-169) According to García-Morales et al. (2012, p. 1041), organizational learning can be seen as a process by which the

organization increases the knowledge created by the individuals in an organized way and transforms this knowledge into part of the organization's knowledge system. Figure 9 presents the system perspective of knowledge management, organizational learning and organizational innovation.

Figure 9. System perspective (Liao & Wu 2010, p. 1098).

As can been seen from Figure 9, knowledge management is an input to the process of organizational learning. Organizational innovation is a critical result of organizational learning. Therefore, organizational learning is closely related to organizational innovation. (Liao & Wu 2010, pp. 1097-1098)

Organizational learning can also be defined as an organization’s ability to renew itself and change its activity. Renewal means the readiness of an organization to acquire new know-how continuously. This acquired know-how can be the core competence of a business or the kind of know-how that is tied to the organization’s actions, processes and instructions. The most typical processes that support organizational renewal are processes related to strategy, knowledge, skills and performance. (Sydänmaanlakka 2001, p. 50) According to Hätönen (2000, p. 8), an organization may use learning to change not just itself, but also its operating environment. One of the key challenges to management is to understand the role of knowledge and learning in organizational change and business success (Pawlowski 2001, p. 61).

Organizational learning differs from individual and team learning. Firstly, organizational learning occurs through the shared insights, knowledge and thinking models possessed by the organization’s members. Secondly, organizational learning is based on earlier knowledge and experience, which is presented in the business’s modus operandi, processes and instructions. (Sydänmaanlakka 2001, p. 50) According to Senge (1990, p. 139), organizations only learn through individual learning. He also states that in spite of this, individual learning does not by itself guarantee organizational learning, but that the latter is not possible without the former. Organizational learning can also be described using a learning cycle, which is presented in Figure 10.

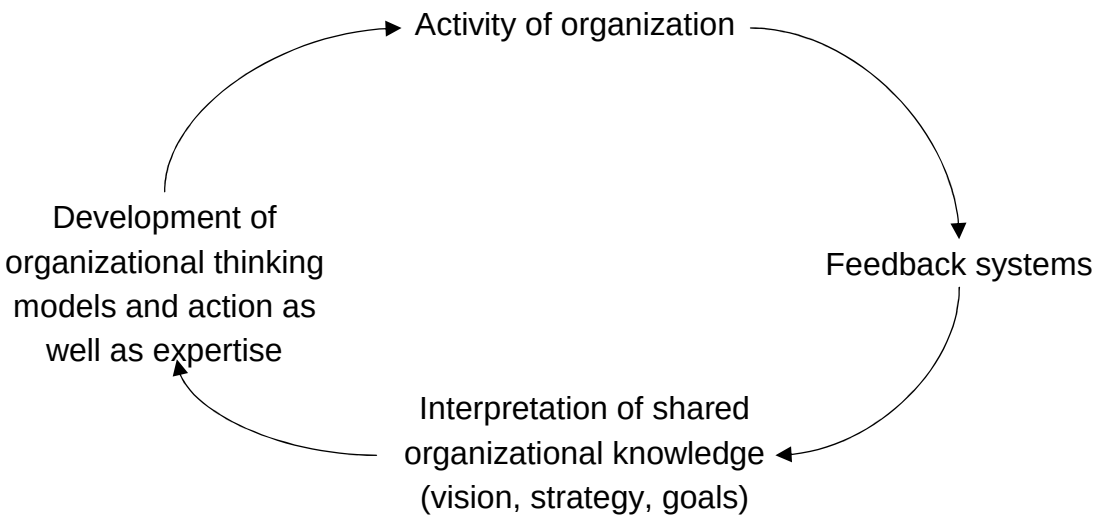

Figure 10. Organizational cycle of learning (Sydänmaanlakka 2001, p. 51).

According to Sydänmaanlakka, the starting point for the organizational cycle of learning is the current activity, on which multifaceted feedback is collected systematically. The knowledge generated by this feedback system is interpreted together. This helps to clarify the organization's vision, strategy and goals. After this, the organization's thinking models, actions and know-how can be developed. Feedback systems thus have an important role in organizational learning. Strategic learning is also emphasized, together with the ability of the management and the entire organization to read weak signals and to renew itself. (Sydänmaanlakka 2001, p. 50)

An organization's activities and feedback systems depend on the organization's capabilities. This research presents applications which can be used to assess an organization's learning environment and new knowledge creation. These applications can be used to interpret the organization's shared knowledge. On the basis of the results of the assessment, the factors having the largest proactive vision can be seen. This knowledge can help the development of the organization's thinking models, activities and know-how. Thus, the use of these applications can be seen as one constituent part of the organizational cycle of learning.

Otala (2000, pp. 168-169) presents the following different approaches to organizational learning:

- The organizational cycle of learning.
- The combination of tacit knowledge and explicit knowledge to create new knowledge.
- Learning by questioning.

- Learning by doing.
- Learning through scenario work.
- Learning from good practices.
- Team learning as a “mini-organization.”

In this research, learning by questioning is selected for closer examination from these different approaches to organizational learning. In this approach to learning, the concepts of single-loop and double-loop learning are central. Single-loop learning is an example of superficial corrections related to learning, leaving the operational model unchanged. Double-loop learning is a more in-depth learning, which means that the theory related to activity is also changed.

Single-loop learning. Argyris and Schön define single-loop learning as instrumental learning that changes ways of acting and their background assumptions while leaving the theory related to activity unchanged from what it was before. Ways of acting and their background assumptions are changed so that the organization’s level of performance stays within the existing values and norms. (Argyris & Schön 1996, pp. 20-21) According to Otala (2000, p. 178), single-loop learning can also be called “learning from feedback”. Single-loop learning solves current problems. Therefore it does not solve the core of the problem: why these problems exist at all. (Argyris 1990, p. 92) The principle of single-loop learning is shown in Figure 11.

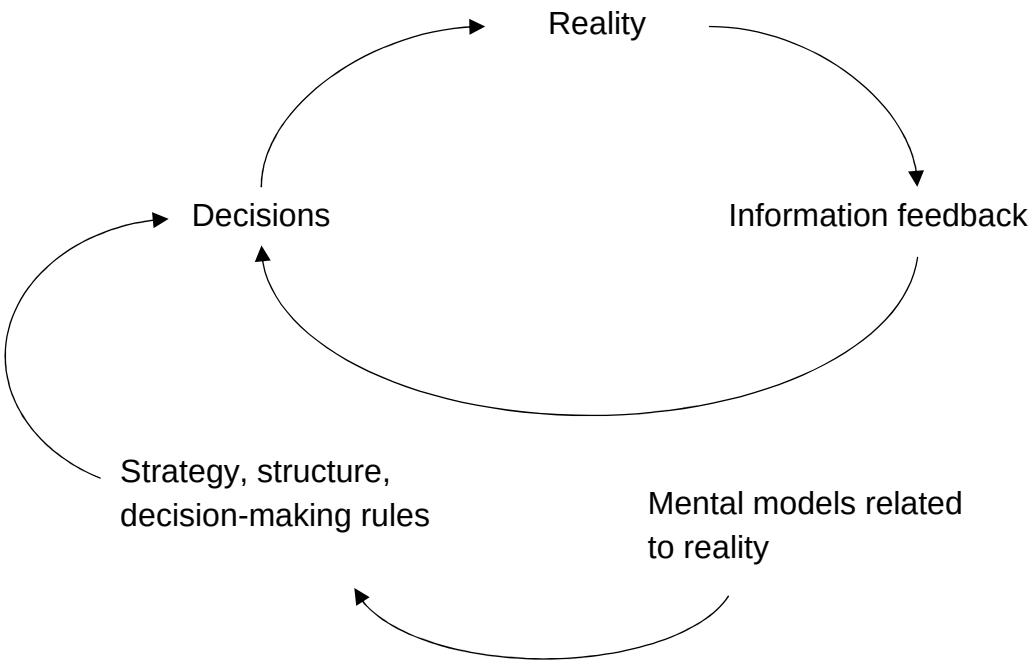

Figure 11. Single-loop learning (Sterman 2000, p. 16).

According to Sterman, single-loop learning describes the most thorough type of learning. In this type of learning, information concerning the state of reality is compared to many kinds of goals. Differences are detected between the current state and the target state and actions are taken to get closer to the latter. Information feedback on reality is not the only input related to decisions. They are also affected by rules on decision-making, which are themselves formed by strategy, structure and cultural norms. The rules concerning strategy, structure and decision-making are steered by mental models related to reality. When the mental models stay the same, we can speak of single-loop learning. This is a process where one learns to reach current targets in terms of existing mental models. (Sterman 2000, pp. 15-16)

Double-loop learning. Argyris and Schön define double-loop learning as learning that results from changes in the theory concerning practice and also from changes in ways of acting and their background assumptions. Ways of acting and assumptions may change at the same time as the theory concerning practice or as a result of changes in the theory. Double-loop learning may result from the actions of individuals, as their own questioning leads to changes in the theory concerning their actions. Individuals may also act on behalf of an organization, when questioning may lead to changes in the theory concerning the organization's activities. (Argyris & Schön 1996, p. 21) According to Otala (2000, p. 179), questioning is a way of learning in everyday work that easily leads to the seeking of new knowledge and learning of new things. The principle of double-loop learning is presented in Figure 12.

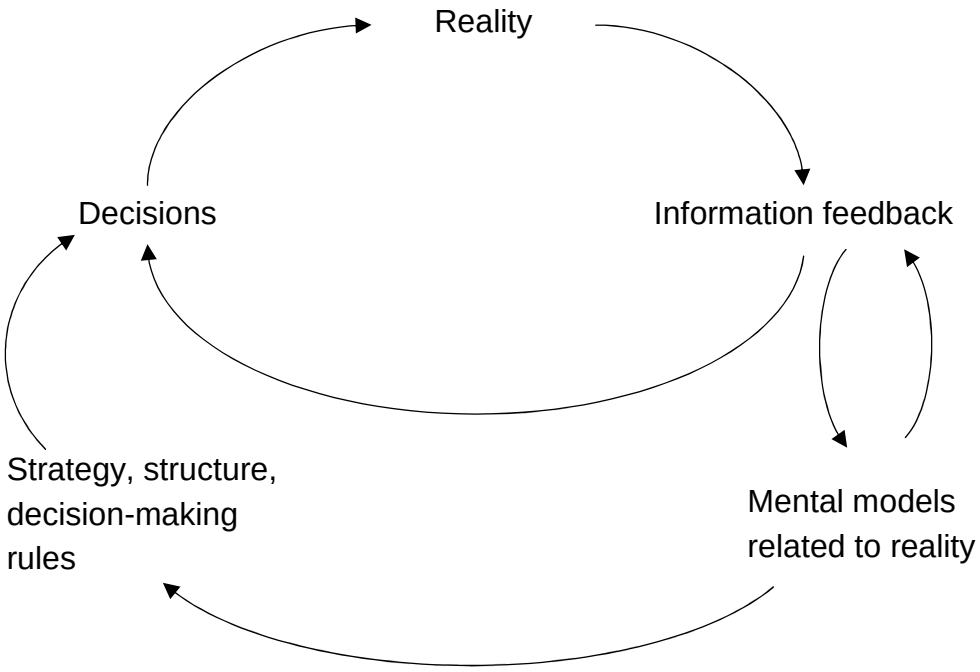

Figure 12. Double-loop learning (Sterman 2000, p. 19).

In double-loop learning, the information feedback on reality affects not just decisions and their background factors, but also mental models. New structures, decision-making rules and strategies are created as the mental models change. As the feedback affects the structure of the system, models concerning behaviour are also changed. The development of systems thinking is a double-loop learning process. A narrow and static short-term view of the world is replaced with a holistic and dynamic long-term view which reshapes practices and rules. (Sterman 2000, p. 18)

2.1.4. The learning organization

According to Otala, a learning organization can be given several different definitions. A learning organization uses the ability to learn of all individuals and groups to achieve its goals. A learning organization also creates an atmosphere that encourages learning by stimulating internal competition, encouraging experimentation, tolerating failures and transmitting knowledge. It is important to encourage all members to learn and to give everyone equal opportunities to learn. (Otala 2000, pp. 162-163)

Typical elements for learning organizations are a low level of organization, staff participation and a shared view of the goals of the activity. Openness and critical assessment of one's own actions are also important features. In a learning organization, active interpersonal interaction has a significant role. The ability to make the necessary changes and development activities efficiently is also emphasized. (Sarala & Sarala 1996, p. 54) A learning organization is often also associated with training, good personnel management, quality management or team organizations. The term "learning organization" does not have a generally accepted, unequivocal content. It is a question of agreement and application. (Moilanen 2001, p. 13)

Sydänmaanlakka (2001, p. 51) defines a learning organization as the kind of organization that is able to adapt, change and renew itself according to the environment's demands; the organization learns from its experiences and is able to change its ways of acting quickly. According to Senge (1990, p. 3), learning organizations are the kinds of organizations where people have the opportunity for continuous development in order to achieve the results they want, where the birth of new thinking models is encouraged and where people continuously learn how they can learn together. Garvin (2000, p. 11) defines a learning organization as an organization which is able to create, acquire, interpret, transmit and store knowledge and to change its behaviour purposefully to meet new knowledge and views.

Vanhala et al. (2002, p. 215) have noted that while a learning organization has received many definitions, there are two requirements that arise when some less operational definitions are ignored:

1. The ability to produce, acquire and transmit knowledge.
2. The ability to carry out in business the kinds of activity and change that correspond to the new knowledge.

The operating model of learning organization always has the conscious aim of improving the skills of personnel in the background of the division of labour and the activity carried out. The skills of learning to learn and multiple skills are emphasized in both the development of the firm's own personnel and in the skill development services offered to others. In a learning organization, the viewpoints of learning and work are combined as well as possible. One key challenge is the smooth and cheap dissemination of skills in both one's own organization and that of one's clients. Personnel train each other as part of the normal working time and wages. (Sarala & Sarala 1998, p. 41) The various definitions seem to share the emphasis on the connection between learning and change, changes to ways of working and acting, delegation, and the presentation of a management style that furthers learning (Sarala & Sarala 1996, p. 54).

The learning organization as a whole can be described with the following framework, which is presented in Figure 13. As can be seen, the constituent parts of a learning organization are vision and goals, corporate culture, leadership, organizational structure, knowledge management and results. The learning processes on individual, team and organization levels are supported by using the support processes for learning and the development processes for skills. These make it possible for organizations, teams and individuals to learn. They promote learning and utilize the basic structures of the learning organization. (Otala 2000, pp. 190-191)

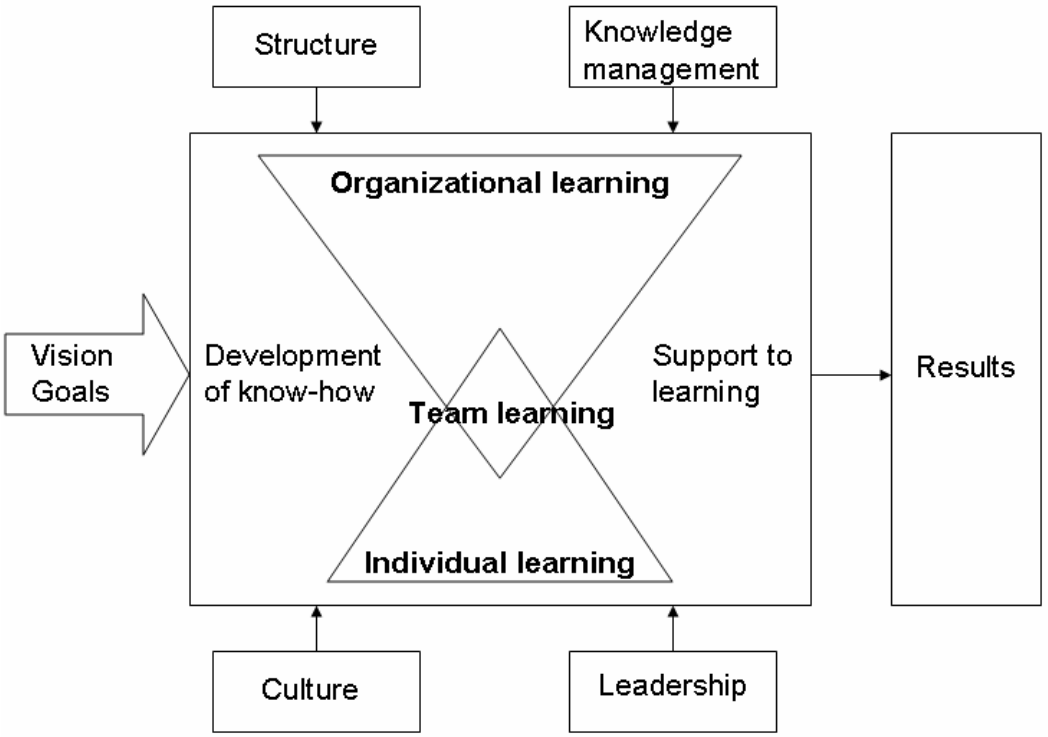

Figure 13. Learning organization (adapted from Otala 2000, p. 191).

The basis for the activities of the learning organization is a shared vision. The learning organization must have a clear and concrete goal and it must know what it wants to be. The entire organization must know the vision and the goals. The vision must be shared and it must offer organization members an opportunity to commit themselves and identify themselves with the organization. All members have the opportunity to contribute to the creation of the vision. (Otala 2000, p. 192; Hätönen 2000, p. 9) According to Sydänmaanlakka (2001, p. 57), the vision of the organization ensures that people progress in the same direction; the vision must govern the activity of the entire organization in relation to the development of skills. A learning organization must re-identify facts and the current situation at given intervals to enable the necessary development (Hätönen 2000, p. 9).

The corporate culture of a learning organization is based on values. The culture has to be open and encouraging. Continuous questioning is one way of acting. The organization invests in a culture of continuous development and improvements are compared with the added value produced to clients. The organizational culture emphasizes the value of expertise and learning through the language and terminology used. (Otala 2000, pp. 194-197) A change in working culture is a long-term learning event, but short-term results demonstrate the need for the change. The working culture of a learning organization is characterized by shared responsibility and learning. (Hätönen 2000, p. 10)

According to Otala, leadership in a learning organization is a way of acting, where everyone is responsible for their own work and its development. It is important for everyone to know the shared goal to prevent people from steering themselves in directions of their own. The most important task for manager in a learning organization is to form a vision and sell it to the organization so that everyone wants to be a part of it. (Otala 2000, p. 199) The management of a learning organization can be examined from the viewpoint of the whole organization and also from the viewpoint of the people who work there. The areas to be examined are the same on both levels, but the emphasis differs. The organization-level dimensions of a learning organization are the following: builder of a learning organization, pathfinder, questioner, creator of preconditions and assessor of the whole. The individual-level dimensions of a learning organization are the following: leader of learners and learning, source of inspiration, initiator, pointer to available means and assessor of learning. (Moilanen 2001, p. 165, 167)

The structure of a learning organization is flexible and contains both chaos and order at the same time. An organization of this kind functions as an open system, and the processes are what form the organizational structure. Teams work with the organization as the basic unit and the organization has several overlapping organizations. The organization also has a capability to organize itself. It has a strong core that ties its parts together and combines different processes. A learning organization covers all interest groups. (Otala 2000, p. 201) Hätönen states that a learning organization is capable of coping with surprising situations and changes by using flexibility. Flexible activity is based on teams that include people from the different functions of the organization. The teams then make use of all available knowledge. (Hätönen 2000, p. 11)

According to Otala, the management and free transmission of knowledge is one basic prerequisite of learning organizations. All learning in the organization is based on the ability of individuals, a team or an organization to handle and refine knowledge. In learning organizations, the availability and mobility of knowledge is being measured constantly (Otala 2000, p. 205). According to Sydänmaanlakka, only shared knowledge is power and for this reason, the sharing of expertise and knowledge is critically important. The sharing of knowledge and expertise is a basic precondition for efficient learning in the organization. (Sydänmaanlakka 2001, p. 57)

The results are related to the goals that the organization wants to reach. The people acting in a learning organization take continual care of their own skills and ability to work. Besides the individual and the organization, this also affects

the wider society; the results also have social effects outside the organization. (Otala 2000, pp. 214-215)

A learning organization provides a positive learning environment for its members. According to Tannenbaum (1997, pp. 439-441), the following matters are reflected in an organization's positive learning environment:

"Individuals are aware of the big picture", having a shared understanding of what the organization aims to achieve and how their own unit and work relate to the work of others in the organization. Awareness of the whole may also help individuals to combine their own personal aims with the aims of the organization. This also increases the likelihood of individuals' ideas and suggestions being essential to the organization and rewarded by it.

"Individuals are assigned tasks where they can apply what they have learned and where they are stretched and challenged". If there are no opportunities for using new skills, this not only depresses the individuals' motivation to learn in the future; it also leads to weakening of the skills due to lack of use.

"Mistakes are tolerated during learning and early application, when individuals are trying new ideas and skills". When the organization assigns employees to tasks with a low probability of error, this may send the message that errors are not tolerated and that learning at work and trying out new ideas may threaten an individual's career. The fear caused by this may hinder the learning, initiative and innovativeness of individuals. Errors may offer a valuable learning experience if they are handled correctly.

"Individuals are accountable for learning, and performance expectations are high enough to necessitate continued personal growth". This responsibility and high level of expectations sends the message that learning is an essential part of success. In addition, responsibility means that the individual's ability to solve problems with new ideas and skills is taken into account.

"Situational constraints to learning and performance are identified and minimized". These kinds of requirements, such as unclear task descriptions, lack of tools and supplies, insufficient personnel, colleagues' deficient skills and lack of time, may affect the ability to acquire new skills. These factors may also weaken the motivation to learn and cause inefficiency. If an individual believes that new skills cannot be utilized, there is no motivation to learn them.

"New ideas are valued and encouraged". Thinking, problem solving and suggestion making are not just the responsibility of the management, but also the task of everyone in the organization.

"Supervisors and co-workers provide support allowing individuals to learn and attempt to implement new ideas". It has been noted that social support has a very strong effect on the efficiency of learning.

"Policies and practices support the effective use of training". A suitable training policy and practice will maintain continuous learning. These factors ensure that the opportunities to learn are available, essential, and applicable to the work. This also ensures that the expectations of participants in the training are met. It has been shown that this increases commitment and motivation after the training.

2.1.5. Disciplines of the learning organization

According to Peter Senge, learning organizations are differentiated from traditional authoritarian organizations by their grasp of certain disciplines. For this reason, the disciplines of a learning organization are central. The five disciplines are systems thinking, personal mastery, mental models, shared vision and team learning. The following is a brief presentation of the key content of each discipline: (Senge 1990, pp. 5-11, 68-269)

Systems thinking is related to seeing wholes and relations instead of seeing just parts. The core of systems thinking lies in a change in ways of thinking. Instead of linear causal chains, one comes to see mutual connections and instead of mere descriptions of various situations, one sees the processes that affect change. Systems thinking is a cornerstone for the way learning organizations see their world. The basic assumption of systems thinking is that each thing affecting a system is both a cause and a consequence. Thus, nothing ever has an effect in just one direction. The practice of systems thinking starts from understanding the concept of feedback. It shows how actions can reinforce or balance each other. Many feedback processes contain “delays” that cause the consequences of activity to be seen only gradually. When systems thinking is practiced, we must abandon the idea that somebody must always be responsible for things. From the viewpoint of feedback, everyone is responsible for the problems arising in a system. But this does not necessarily mean that everyone has the same power to change the system.

The art of systems thinking is in the ability to see the structures behind the complexity that cause changes to occur. Without systems thinking, all the

disciplines of a learning organization cannot be combined with each other after they have been applied. All five disciplines are affected by a change in ways of thinking. Instead of parts, one sees wholes and people are seen as active participants in the modification of reality, not as helplessly reactive observers. They are also seen as creating the future rather than simply reacting to the current situation.

Personal mastery is a discipline used to sharpen and deepen one's own personal vision continuously. It also concentrates one’s own energy, improves patience and helps one to see reality in an objective way. Thus, personal mastery forms the mental basis for the learning organization. The organization cannot be more committed and able to learn than its members. People whose personal mastery is high are able consistently to achieve the results that mean the most to them. As a consequence, they are committed to lifelong learning. Personal mastery is a process that continuously sharpens one’s personal vision of what one wants to be. The personal vision comes from within. The cornerstone of personal mastery is the ability to concentrate on fundamental inner desires instead of secondary goals. For many, sharpening vision is an easy area of personal mastery compared to facing the current situation. The difference between the vision and the current state generates “creative tension”. This is the force that aims to bring the current state closer to the vision. If there were no difference between the two, there would be no need for actions to take one closer to the vision.

Creative tension can be defused in two ways: either by bringing reality closer to the vision or by bringing the vision closer to reality. Which of these two is realized depends on whether the vision is kept unchanged. The key to personal mastery is in learning how to create and maintain creative tension. Here, learning does not mean the acquisition of new information. Instead, it expands the ability to achieve the results one really wants in life. People whose personal mastery is high are committed and venturous. They also learn faster than others and have a wider sense of their responsibility at work.

Mental models are deeply rooted assumptions, generalizations or images that affect one’s own worldview and actions. People are often unaware of the effect mental models have on their behaviour. Work with mental models begins from learning to present one’s own inner worldviews and hold them up to examination. This also includes the ability to maintain discussions where people reveal their own thoughts and receive influences from others. According to Senge, ignoring of mental models has weakened attempts to help the practice of systems thinking. Deeply rooted mental models prevent the changes that could otherwise follow from the application of systems thinking.

Mental models and systems thinking belong together naturally. One of these reveals hidden assumptions while the other concentrates on how we rebuild assumptions in order to reveal the consequences of significant problems. Managers must learn to assess their own mental models. There is no reason to expect mental models to change before the prevalent assumptions are brought into view. If the managers consider that their own worldview is a fact instead of an assumption, they are unable to assess their worldview. If the organization has no principles or understanding in relation to the prevalent mental models, people will misunderstand the purpose of systems thinking. It is important to apply systems thinking to enable efficient work with mental models.

Shared vision is central to learning organizations, as it produces the focus and energy needed for learning. Shared visions have their origins in personal visions, which give them the necessary energy and promote commitment. In relation to the building of shared visions, it is important to encourage organization members to develop their own personal visions continuously. If people do not have personal visions, they will submit to the vision dictated by others and fail to commit themselves to it. The first step towards managing the building of shared visions is to abandon the traditional idea that visions always come from the management of the organization. Managers must also share their own personal visions continuously to enable the building of shared visions. Managers must also communicate the vision in a way that encourages others to share their own personal visions.

A common vision will not necessarily change in any essential way when several people share it. A shared vision becomes more vivid and real from the viewpoint of the mental reality which people imagine they will reach. As a result, people will become partners with each other and the vision is no longer dependent on any one person. A shared vision is a vision to which several people are really committed because it reflects their own personal visions. A shared internal vision of this kind will in turn raise the people’s own goals. Shared visions force people to act so naturally that they will not even notice the extent of their own activity. In companies, the relationship of people with the company will change, and people will see the company as “our company”. There cannot be any learning organization without shared visions, as the vision constitutes the aim that brings everyone in the organization together. A shared vision keeps the learning process alive even when setbacks arise. Shared visions also increase risk-taking and experimentation.

Team learning starts from the practice of dialogue, as a consequence of which people will start thinking together. The practice of dialogue also includes the recognition of the practices related to team interaction that may hinder learning.

Team learning is important, because it is teams and not individuals that form the basis of modern organizations. If teams are unable to learn, the organization cannot learn either. Team learning is a process that develops the team's ability to achieve the results the members really want. Of all the disciplines of the learning organization, team learning is built on a shared vision. It also builds on personal mastery, as proficient teams consist of proficient individuals. However, shared vision and talent are not enough to guarantee team learning.

In organizations, team learning has three important dimensions. Firstly, there is a need to think accurately about complex things. Teams must learn to utilize the potential of several brains to become more intelligent than a single brain. Secondly, there is a need for innovative, coordinated action. Excellent teams develop the kinds of relations where each member is aware of the other members. The members should also be able to act in ways that complement the actions of other members. Thirdly, there is the role of team members in other teams. A learning team continually improves the activity of other learning teams by clarifying the skills and practices of team learning in a wider way.

In team learning, discussion is a necessary counterpart to dialogue. In discussions, different views are presented and defended and decisions are made. A dialogue, on the other hand, presents different views in order to find new viewpoints on the matter at hand. Team learning also involves learning how working groups can handle the forces that oppose dialogue and discussion. These defensive routines hinder learning. But if a solution is found to free the energy they contain, they also have a great potential for promoting learning.

2.1.6. Barriers to learning

According to Moilanen, organization-level barriers are organization-specific. Before the situation is analysed and examined critically, it is hard to define the factors that hinder or slow down organizational development and personal learning. Anything on the organization level can be a barrier: for instance, management systems, incentive systems, shared unwritten rules, action-governing principles, workspace arrangements, organizational structure, lack of shared direction and goals, application of wrong methods, or deficient assessment systems. (Moilanen 2001, p. 93)

Senge states that most organizations are bad at learning due to the ultimate factors that cause an inability to learn. These factors may be caused by the way the organization is designed and managed or by the way the work tasks of members of the organization are defined. The manner in which members are

taught to think and interact both inside and outside the organization is also apt to cause an inability to learn. According to Senge, these factors continue to exist despite the best efforts of committed people. The first step towards removing these factors is the recognition of the following seven factors (Senge 1990, pp. 18-25):

1. Organization members concentrate on their own work. They do not have an understanding of the responsibility related to results when the organization functions as a unity.
2. When things go wrong, some outside factor is always blamed and the effects of one's own actions over task borders are not seen.
3. An overemphasis on proactiveness. The effect of one's own actions on one's own problems is not seen.
4. Concentration on short-term events instead of seeing the long-term changes that gradually affect events in the background.
5. An inability to see the phased processes that often form the biggest threats.
6. Organizations learn best through experience, but the consequences of the most important decisions are not often experienced directly.
7. Organizations reward people who are good at defending their own opinions, not people who dare to question complex things.

Otala believes that the ability to learn can be improved by recognising and dismantling factors that prevent organizational learning. Otala (2000, pp. 258-261) defines these factors as follows:

- Rigid and time-consuming routines leaving no time or energy for learning.
- People do not learn from experience; organizational memory is not utilized.
- People do not learn from mistakes; they are not utilized and analysed immediately to enable learning.
- The management team is dysfunctional; managers do not communicate with each other or shared thinking models are lacking. Management is unable to make decisions efficiently.
- An excessive concentration on action; management and the entire activity of the organization is concentrated on the present, while the vision and the goals are unclear.
- A belief in permanence; it is believed that the level already reached will still be sufficient tomorrow.

- Tight borders between different departments, preventing the formation of teams and the transmission of information in different directions in the organization. This prevents the entire organization from learning.
- Organizational rigidity, which may prevent learning if the organization is unable to change and act in a new way.
- Formal communication, which may prevent learning if the organization uses written and formal communication from the top down or reports from the bottom up. This prevents the creation of shared thinking models and interaction between individuals.
- Slow changes are not detected, and as a consequence, the organization does not react to them until it is too late.
- Experiential knowledge is forgotten; it is not analysed or treated as systematically as exact knowledge.
- Differences are whittled down; there is no multifaceted interaction or sufficient questioning between organization members. As a result learning will suffer.

On the basis of the theoretical considerations above, it can be stated that the concept of the learning organization is important and significant for assessing organizational learning. From this theoretical part, it follows that an assessment system for examining learning environments should also include concepts and indicative factors that describe organizational learning.

2.1.7. Key findings for ontology building

Learning can occur on the level of an individual, a team or an organization. Organizations function as systems where members of the organization learn in the daily working environment. This environment should reflect the disciplines of the learning organization. There must be a shared vision for an ideal learning environment. One sub-goal of this research is to construct an ontology describing the learning environment. Based on a literature review, Tannenbaum's (1997) learning environment measurement tool is selected as the focus of this research. This tool includes features which can be used to obtain a view of a positive learning environment (Figure 14). These features are used when constructing an ontology for a learning environment.

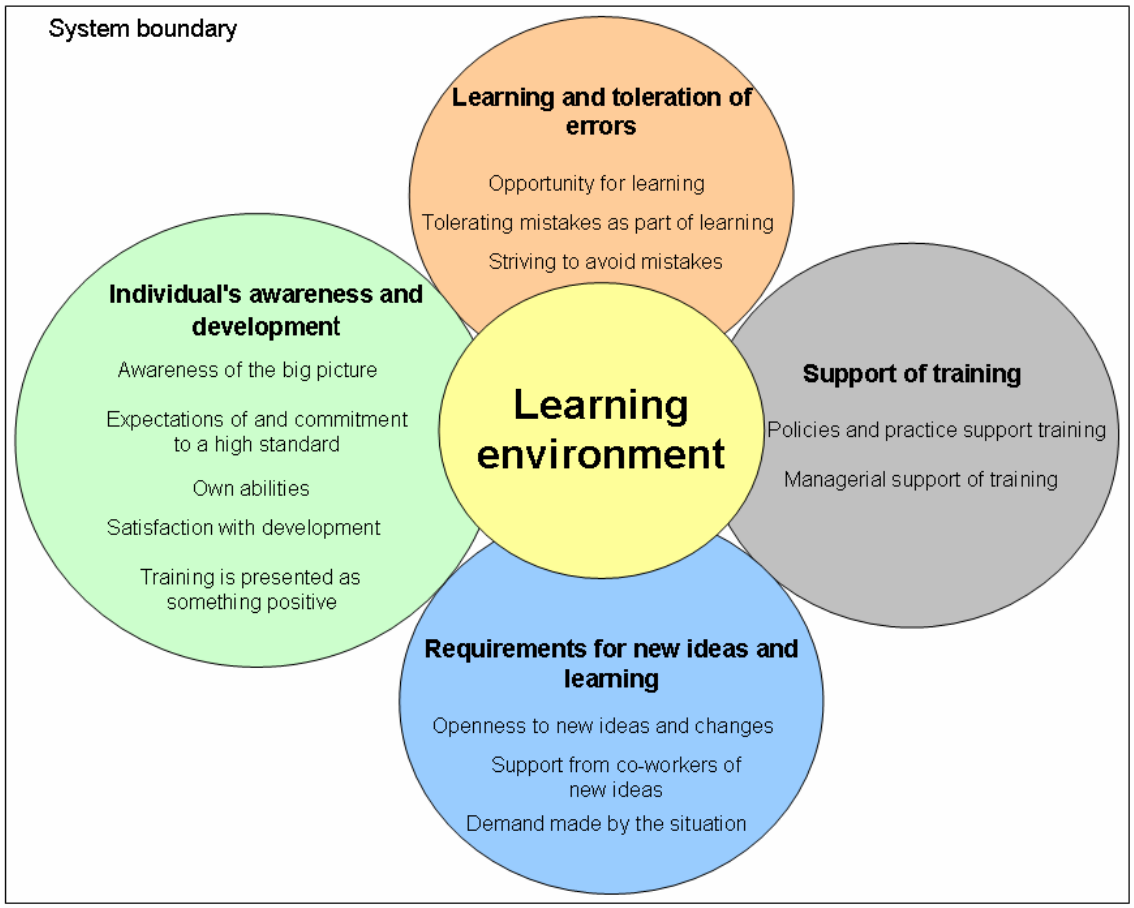

Figure 14. Features of a positive learning environment (cf. Tannenbaum 1997).

Learning takes place inside the boundaries of the organization. The learning environment can be seen as a management object which needs to be developed continuously. Without understanding the content of this management object, development is not possible. With the help of Tannenbaum's measurement tool, it is possible to understand better the concepts related to learning and developing a positive learning environment.

2.2. Definition of knowledge creation

Otala (2000, p. 209) views knowledge and skills as strategic resources that must be managed and developed in the same way as other resources. According to Sydänmaanlakka (2001, p. 176), when we talk about knowledge, it is good to start from a definition of what knowledge is. This will enable better management of knowledge. Knowledge is not data or information, although it is tied to both of these. The success or failure of an organization can often depend on knowing which of these three is needed, which of them are already possessed and what can or cannot be done with each of them. To enable successful work related to knowledge, it is important to understand what these

three factors are and how the relations between them are formed. (Davenport & Prusak 1998, p. 1)

Data contains numbers, text, images or various combinations of these. Data is the raw material of information. Data is loose knowledge that does not contain relations or meanings. (Sydänmaanlakka 2001, p. 176) All organizations need data, and some branches of industry are heavily dependent on it. Data is important for organizations, as it is a necessary raw material for the creation of information. (Davenport & Prusak 1998, pp. 2-3)

According to Ruohotie (2000, p. 254), information consists of ideas, images, sounds, figures, numbers, statements and facts. Information is like a message, which is often found in the form of a document. It can also be communication related to hearing or seeing. Information must have a sender and a recipient. Information intends to change the way the recipient perceives something. Information has an effect on the views and behaviour of the recipient. (Davenport & Prusak 1998, p. 3)

Knowledge is personal and is born out of one's own immediate experience. Knowledge is related to earlier knowledge and is shaped by its context. Knowledge is the result of thinking, which is born out of an interest in some object. According to Ruohotie, intellectual activity and knowledge is born where the interest of humans is focused. The objects of natural human interest become areas of knowledge formation. (Ruohotie 2000, pp. 254-255) Davenport and Prusak (1998, p. 5) define knowledge as follows: "Knowledge is a mix of framed experiences, values, information, and insights that provides a framework for evaluating new experiences and information. Knowledge originates and it is applied in the minds of knowers. In organizations, knowledge is often embedded in documents, routines, processes, practices and norms."

The nature of knowledge can be either objective or subjective. When it is objective, the knowledge is independent of the individual and it is "certain" knowledge that resides outside the individual. When knowledge is subjective, we talk of individuals' own knowledge that is internalized and formed by them. When using subjective knowledge, individuals are in contact with the surrounding reality. The practical knowledge, deduction and skills of individuals are thus related to a certain kind of tacit knowledge. This means the wordless knowledge in a non-conceptual form that is included in action. Tacit knowledge is knowledge which is created through experiencing. Tacit knowledge can be seen as skilful, intuitive and smooth action. Expertise can be presented as a chain of the type shown in Figure 15. The theoretical and practical knowledge important to individuals is first combined with experience-related knowledge. As

professional experience accumulates, tacit knowledge born through practice is added to the mix. The end result is expertise that cannot be reached through mere training. The expertise needed in work is closely related to the sharing and common use of the tacit knowledge possessed by experts who master their own work and occupation. (Järvinen et al. 2000, pp. 71-73)

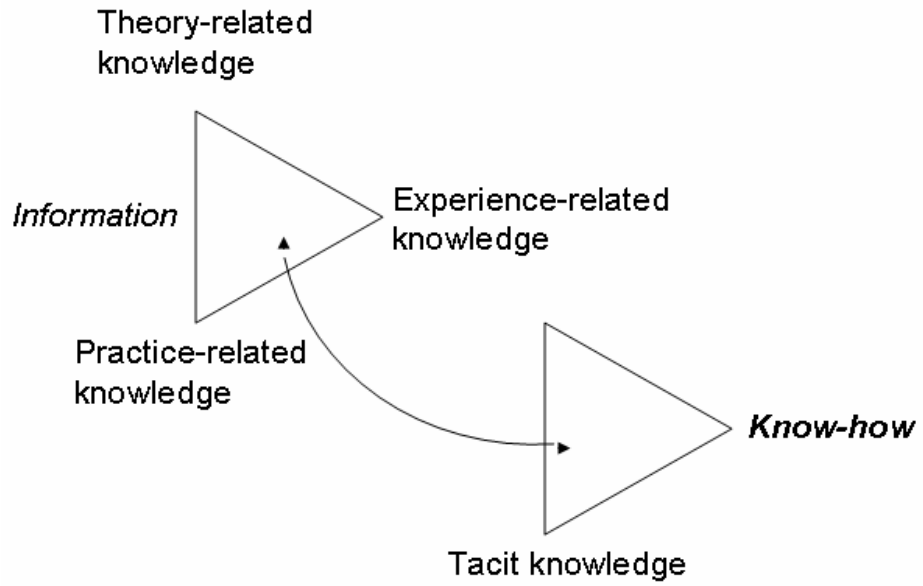

Figure 15. Information, knowledge and expertise (Järvinen et al. 2000, p. 72).

According to Järvinen et al., the multifaceted forms of knowledge found in different kinds of knowledge resources must be known to enable the processing of knowledge in the work community. The multifaceted use of different forms of knowledge can help in creating innovative products. (Järvinen et al. 2000, p. 135, 153) In rapidly changing circumstances, the need to turn tacit knowledge into conceptual knowledge is emphasized. By creating new knowledge, the organization is able to reinforce its own skills and differentiate from its competitors. (Ruohotie 2000, p. 257)

2.2.1. New knowledge creation

Nonaka and Takeuchi state that an organization cannot create knowledge without individuals. Thus, the organization must support creative individuals or offer them a context where knowledge can be created. In the ontological dimension, organizational knowledge creation should be seen as a process that reinforces the knowledge created by individuals and crystallizes it to be part of the organizational network of knowledge. This process crosses over various levels and boundaries within and between organizations. Nonaka and Takeuchi have noted that according to Michael Polanyi, the epistemological dimension of organizational knowledge creation is divided into tacit and explicit knowledge.

(Nonaka & Takeuchi 1995, p. 59) Table 1 presents the characteristics of tacit and explicit knowledge.

Table 1. Tacit and explicit knowledge (Nonaka et al. 2001a, p. 494).

Tacit knowledge (subjective)	Explicit knowledge (objective)
Knowledge related to experience (body)	Rational knowledge (mind)
Simultaneous knowledge (here and now)	Sequential knowledge (there and then)
Analog knowledge (practice)	Digital knowledge (theory)

According to Polanyi, the unique touch of a pianist cannot be learned by merely learning the movements required to play the piano. General experience has shown that no skill can be acquired by learning one by one the movements that constitute the skill. The imitation of movements is helpful, but in the end one must find the right feeling for a virtuosic end result. Knowledge and doing are thus intertwined. (Polanyi 1961, pp. 460-461) This kind of tacit knowledge has a personal nature and is tied to its context. For this reason, tacit knowledge is hard to formalize and communicate. (Nonaka & Takeuchi 1995, p. 59)

Tacit knowledge includes both a cognitive and a technical element. The cognitive element covers mental models, such as generally accepted principles, beliefs and viewpoints. Mental models help individuals to perceive and define their own world. The technical element of tacit knowledge comprises the know-how possessed by an individual. (Nonaka & Takeuchi 1995, p. 60) As Sydänmaanlakka (2001, p. 181) says, tacit knowledge is not documented, and for this reason it is difficult to transfer tacit knowledge to other people.

Choo states that it is difficult to divide tacit knowledge into parts, as it is related to the experience accumulated by individuals through doing. Although it is not in written form, tacit knowledge can nevertheless be taught and shared. This learning of tacit knowledge takes place by example, as when an apprentice follows and copies the master's skills. Tacit knowledge can also be shared with the help of analogy, metaphors, models or stories. (Choo 1998, pp. 116-117) According to Koskinen (2004, p. 15), in practice many experts are not capable of expressing clearly everything they know and are able to do. Neither can they express the way they make decisions.

Explicit or codified knowledge is the kind of knowledge that can be transferred with formal and systematic language (Nonaka & Takeuchi 1995, p. 59). Explicit knowledge can be based on certain objects or rules. Knowledge related to objects is codified in the form of symbols, such as words, numbers and

formulas, or in the form of physical objects, such as equipment, documents and models. Choo has noted that according to Cyert and March, the knowledge related to rules can be divided into organizational work tasks, the keeping of archives, the processing of information and the rules related to planning. (Choo 1998, p. 112) According to Koskinen (2004, p. 15), tacit knowledge is related to how things work, while explicit knowledge is able to explain why they work.

To achieve a better understanding of how organizations create knowledge dynamically, Nonaka et al. suggest that we take into account three elements: the SECI process, the shared context of knowledge creation (Ba), and knowledge assets (Figure 16). To enable the formation of a knowledge spiral, these three elements must interact with each other. (Nonaka et al. 2001b, p. 16)

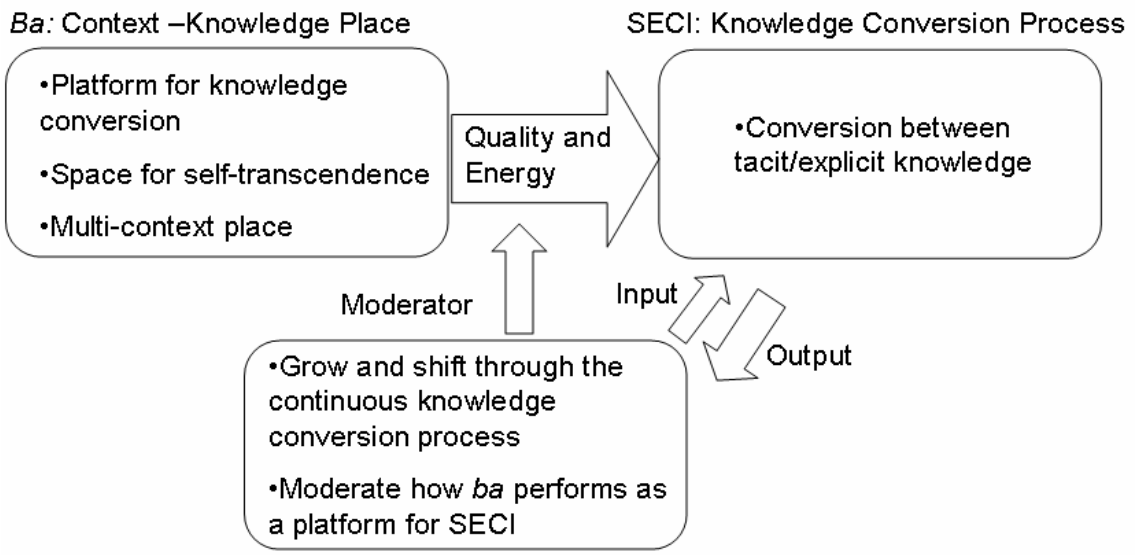

Figure 16. Three elements of the knowledge-creating process (adapted from Nonaka et al. 2001b, p. 17).

2.2.2. SECI process

The organization creates knowledge as a result of the interaction between explicit and tacit knowledge. This interaction is called knowledge conversion. As a consequence of the conversion process (SECI process), knowledge expands in both quality and quantity. The four modes of knowledge conversion are S=socialization, E=externalization, C=combination and I=internalization. (Nonaka et al. 2001b, p. 16) Socialization aims to share tacit knowledge, but by itself it is a limited form of knowledge creation. Knowledge cannot be shared easily with the entire organization if shared tacit knowledge is not put in an explicit form through externalization. The mere combination of parts of explicit knowledge into a new whole does not expand the existing knowledge base of the organization. Internalization, where explicit knowledge is transformed into

tacit knowledge, is closely related to organizational learning. (Nonaka & Takeuchi 1995, p. 62, 70) The modes of knowledge conversion are presented in Figure 17.

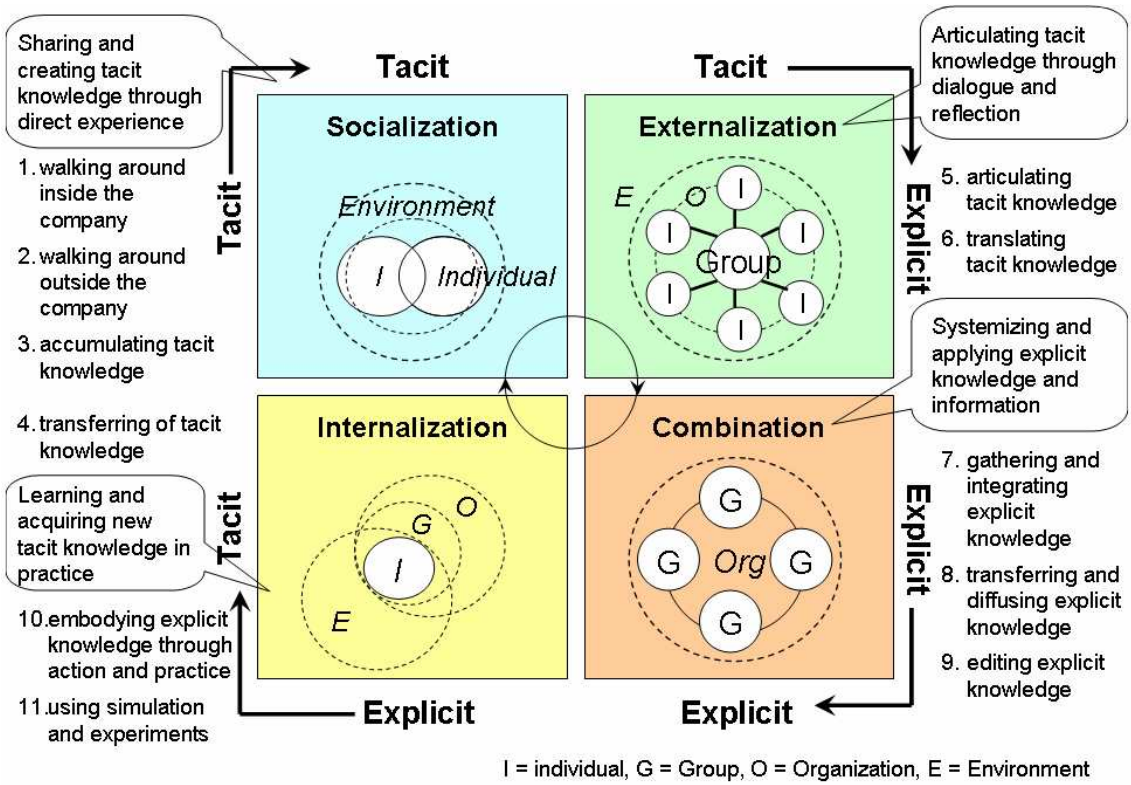

Figure 17. SECI model of knowledge creation (adapted from Nonaka & Toyama 2003, p. 5).

Socialization is a process where people share their experiences and create tacit knowledge, such as shared thinking models and technical skills. Tacit knowledge can be acquired directly from others without speech. According to Nonaka and Takeuchi, the key to acquisition of tacit knowledge is shared experience. The mere transmission of knowledge has only a slight significance if it is separated from the related emotions and the special contexts to which the shared experiences are related. (Nonaka & Takeuchi 1995, pp. 62-63)

In socialization, individuals share tacit knowledge with each other. This can happen when individuals exchange experiences, learn by observing each other at work or spend time together and act together. When time is spent together, people receive a deep understanding of new ways of acting, culture, attitudes, values and emotions. Tacit knowledge is transmitted better in this way than through a written manual or verbal communication. (Suurla 2001, pp. 41-42)

Externalization is a process where tacit knowledge is articulated into the form of explicit concepts. Nonaka and Takeuchi state that externalization is an

essential part of the process of knowledge creation, as it ensures that tacit knowledge takes an explicit form. This happens through metaphors, analogy, concepts, hypotheses or models. Metaphor is a method of conceptualising or understanding a thing intuitively by imagining some other thing in a symbolic way. When we try to conceptualize a metaphor, we express its content mainly in speech. Writing is used, for instance, to transform tacit knowledge into an articulable form. Expressions are often incomplete, inconsistent and insufficient, but these kinds of differences between mental images and expressions nevertheless promote “assessment” and interaction between individuals. Typically, knowledge is externalized in the process of creating concepts that is triggered by a dialogue or a collective assessment. (Nonaka & Takeuchi 1995, pp. 64-66)

Suurla has noted that the process of externalising tacit knowledge is in practice based on two key considerations: the articulation of tacit knowledge and the translation of the tacit knowledge of clients and other experts into an understandable form. In order to articulate tacit knowledge, methods must be used and developed for the expression of tacit knowledge. The use of dialogues is one example. When deep-level knowledge and expertise is shared among professionals, all parties learn something new. (Suurla 2001, p. 42)

Combination is a process where concepts are organized into a knowledge system. As a mode of knowledge conversion, combination comprises the combination of different forms of explicit knowledge. Individuals exchange and combine information through different media, such as documents, meetings, phone conversations and data networks. The rearrangement of existing explicit knowledge through sorting, adding, combination and classification may lead to new knowledge creation. The knowledge generated in schools by teaching and practice often takes this form of changing knowledge. In businesses, combination of knowledge is usually seen when middle management breaks down and operationalizes company visions and the business and product concepts. Innovative use of data networks and large-scale databases makes it possible to combine knowledge. (Nonaka & Takeuchi 1995, pp. 67-68)

According to Suurla, communication and the systematization of knowledge are key elements of combination. In practice, combination takes place in three ways that support each other. Firstly, new conceptual knowledge is adopted and combined with existing knowledge. In relation to the adaptation of new conceptual knowledge, new knowledge is gathered from inside the company or from outside sources. It is combined, adapted and processed into new knowledge. Secondly, the new conceptual knowledge is disseminated to the organization by means of presentations and meetings. Thirdly, the knowledge is

assessed and handled in connection with reports and plans, enabling the organization to make concrete use of it. (Suurla 2001, pp. 42-43)

Internalization is a process where explicit knowledge is translated into tacit knowledge. According to Nonaka and Takeuchi, internalization is closely related to “learning by doing”. When an individual internalizes the experiences received through socialization, externalization and combination as a part of tacit knowledge in the form of shared thinking models or technical know-how, these become a valuable property for the individual. Tacit knowledge accumulated at the individual level must be shared with other members of the organization to trigger a new spiral of organizational knowledge creation. The transformation of explicit knowledge into tacit knowledge is easier if the knowledge is in the form of documents, manuals or expressed stories. Documentation helps individuals to internalize what they have experienced. At the same time it also enriches the tacit knowledge they possess. Documents and manuals make it possible to transfer explicit knowledge to other people. They also help them to experience other peoples' experiences in an indirect way. Internalization can also occur without “re-enacting” the experiences of other people, for instance through reading and listening to success stories. In this case, members of the organization experience the realism and content of the stories that happened in past. In this way past experiences can be adapted as individuals' tacit thinking models. The tacit knowledge created in this way becomes a part of the organizational culture if most organization members share this thinking model. (Nonaka & Takeuchi 1995, pp. 69-70)

According to Suurla, in practice internalization involves two things. Firstly, conceptual knowledge must become visible in both action and practice. Secondly, internalization is supported by using simulations and training, for instance by using virtual learning environments and action networks. Internalization helps in the realization of new concepts and methods in the organization’s strategy, innovation processes, and renewal. (Suurla 2001, p. 43)

Organizations cannot create new knowledge by themselves. Organizations must utilize the tacit knowledge accumulated by individuals. This tacit knowledge forms the basis for knowledge creation in organizations. Tacit knowledge moves in organizations through four modes of knowledge conversion. Tacit knowledge is clarified when it moves to upper ontological levels. Nonaka and Takeuchi call this interaction between tacit and explicit knowledge a knowledge spiral. Organizational knowledge creation is like a spiral process that starts on the individual level and proceeds through the expansion of individuals’ interaction over departmental, divisional and

organizational boundaries. (Nonaka & Takeuchi 1995, p. 72) Figure 18 shows this spiral of organizational knowledge creation.

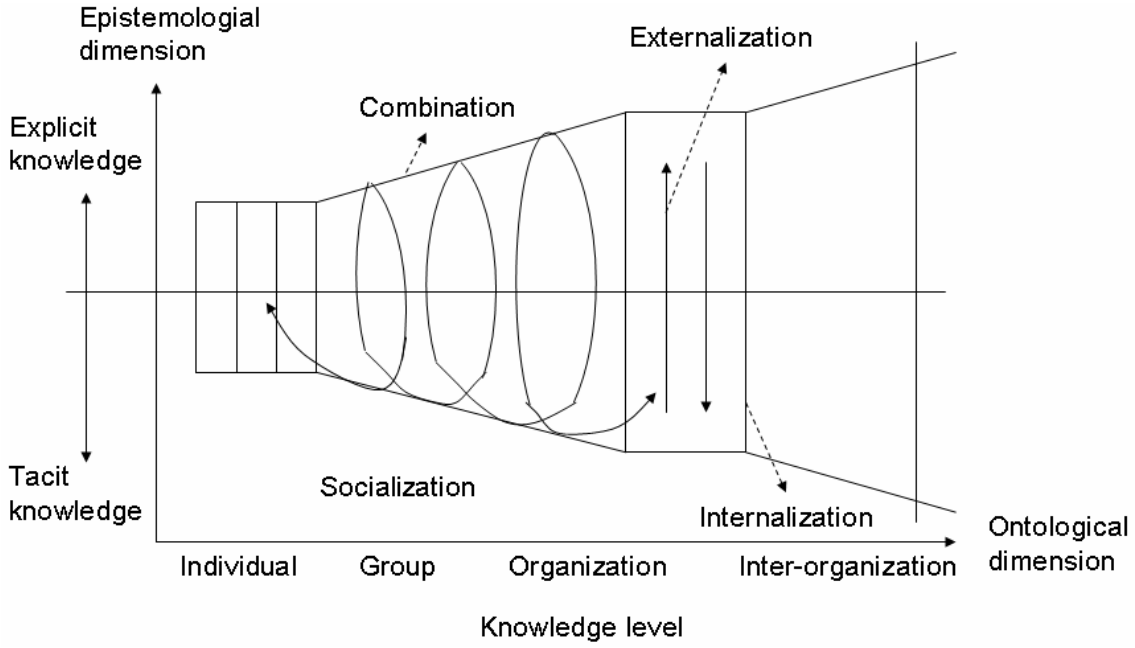

Figure 18. Spiral of organizational knowledge creation (Nonaka 1994, p. 20).

The organization's role in the process of organizational knowledge creation is the production of a suitable context to enable group activities, as well as the creation and accumulation of knowledge at the individual level. Nonaka and Takeuchi (1995, p. 74, 82-85) define five enabling conditions for the building of an organizational knowledge spiral: intention, autonomy, fluctuation and creative chaos, redundancy, and requisite variety. Von Krogh, Ichijo and Nonaka approach knowledge creation in their book *Enabling Knowledge Creation* (2000) from a viewpoint that is closer to practice. They present five factors that enable knowledge creation: instilling a knowledge vision, managing conversations, mobilizing knowledge activists, creating the right context, and globalizing local knowledge.

2.2.3. Knowledge creation context (BA)

The process of knowledge creation is an event tied to a certain context in terms of who participates and how they participate. Knowledge needs a physical context to enable the creation of knowledge. Nonaka et al. call this kind of context "Ba". They define Ba as a shared context where knowledge is shared, created and utilized. From the viewpoint of knowledge creation it is important to generate and regenerate Ba. Ba provides energy, quality and a place for the conversations of individuals. This way it offers an opportunity to move along the knowledge spiral. The creation of knowledge cannot be free from context.

Social, cultural and historical contexts are important, as they provide the basis for interpreting information to create meanings. Thus, Ba is the place where information is interpreted to enable it to become knowledge. (Nonaka et al. 2001b, p. 22)

Ba does not necessarily mean a physical space. Ba combines physical space (e.g. office space), virtual space (e.g. e-mail) and mental space (e.g. shared beliefs). Interaction is an important concept in the understanding of Ba. Nonaka et al. have noted that some of the research on knowledge creation concentrates mainly on individuals. The research is based on the assumption that individuals are the primary force of knowledge creation. However, knowledge creation is a dynamic process close to human beings that transcends existing boundaries. Knowledge is created in interaction among individuals or between individuals and their environment, rather than alone. Ba is the context shared by all those who interact with each other. The participants are committed to Ba through action and interaction. Thus, the participants cannot be mere onlookers. (Nonaka et al. 2001b, p. 22)

According to Nonaka et al., Ba is complex and constantly changing. At the same time, it sets boundary for interactions among individuals. However, this boundary remains open. Participants may come and go with their own contexts, and the shared context can change all the time. As a consequence of the shared context provided by Ba, binding conditions are set by Ba on how participants view the world. In spite of this, Ba offers to participants viewpoints that are wider than their own. Ba gives participants an opportunity to share time and space. This is especially important in the socialization and externalization modes of knowledge creation. From the viewpoint of shared context and common language, physical interaction is important. Ba can be a mental, virtual or physical place, and so it does not need to be bound to a specific time or space. Ba is changing constantly. It is created, it functions and it disappears, according to need. (Nonaka et al. 2001b, pp. 22-24) According to Nonaka and Konno (1998), Ba can be divided into four types: originating, dialoguing, systemising and exercising Ba. These four types are presented in Figure 19.

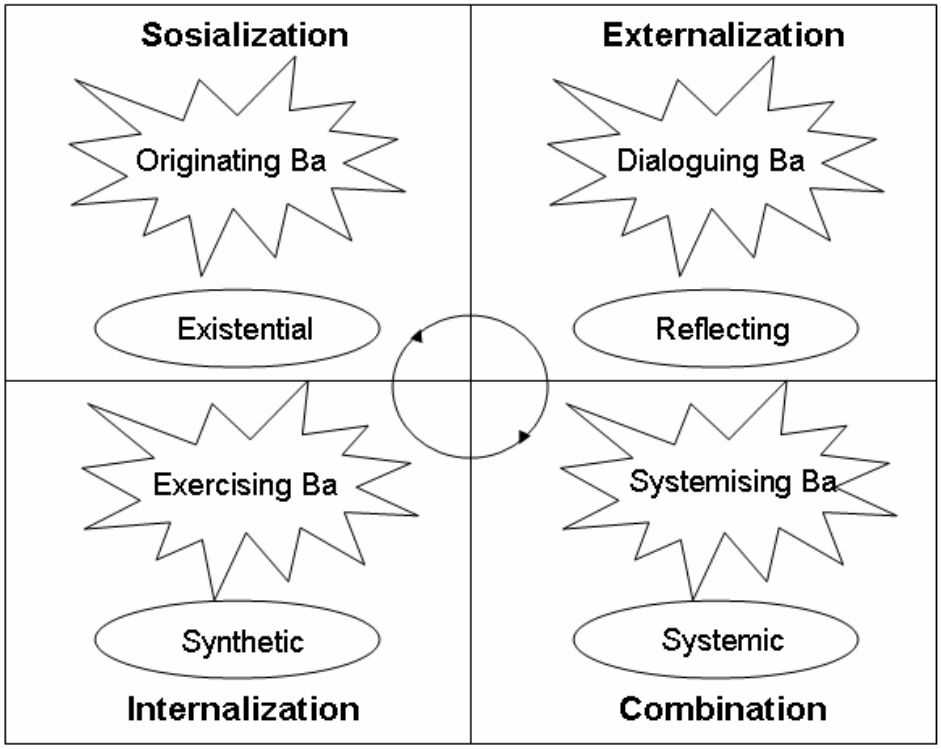

Figure 19. Four types of Ba (adapted from Nonaka & Konno 1998, p. 46).

Originating Ba is characterized by individual and face-to-face interaction. Individuals share their experiences, feelings, emotions and mental models. These face-to-face interactions involve taking account of psycho-emotional reactions, such as ease or discomfort. These are important elements in the sharing of tacit knowledge. Originating Ba offers a place where an individual transcends the boundary between self and others. Originating Ba enables manifestations of care, love, trust and commitment, which function among individuals as the basis for knowledge conversion. (Nonaka et al. 2001b, pp. 24-25) According to Nonaka and Konno (1998, p. 46), originating Ba is the place where the knowledge-creating process starts. It corresponds to the mode of socialization.

Dialoguing Ba is characterized by collective face-to-face interaction. According to Nonaka et al., this type of Ba is primarily a context for externalization and it is also a place where individuals can share mental models and skills. Concepts are born out of this sharing. Individuals articulate and share tacit knowledge through dialogues amongst participants. Dialoguing Ba is constructed more consciously than originating Ba. In relation to dialoguing Ba, the key to managing knowledge creation is the selection of individuals who possess specific knowledge and capability. (Nonaka et al. 2001b, p. 25)

Systemising Ba is characterized by collective and virtual interaction. Systemising Ba is primarily a context for the combination of existing explicit

knowledge. This kind of knowledge is easy to transmit in written form to a large number of people. According to Nonaka et al., information technology such as on-line networks, groupware, documentation and databanks can offer a virtual collaborative environment for systemising Ba. Organizations can use electronic mailing lists and news groups to exchange necessary information or to answer questions. This improves the efficiency of collecting and disseminating knowledge and information. (Nonaka et al. 2001b, p. 25) This type of Ba corresponds to the mode of combination, where new knowledge in explicit form is combined with existing information and knowledge. As a consequence, new knowledge is created and organized throughout the organization. (Nonaka & Konno 1998, p. 47)

Exercising Ba is characterized by both individual and virtual interaction. According to Nonaka et al., this type of Ba offers primarily a context for internalization. Exercising Ba embodies the explicit knowledge communicated through virtual media, such as written manuals or simulation programs. Exercising Ba synthesizes reflections that come through action, while dialoguing Ba achieves this through thought. (Nonaka et al. 2001b, p. 26)

Nonaka et al. state that when management builds Ba purposefully, the right kinds of people must be selected to further mutual interaction. Managers must also find and utilize spontaneously generated Ba, which can change or disappear quickly. Managers must also be aware of how members of the organization interact with each other and with the outside environment. This way, naturally generated Ba can be utilized rapidly and purposefully generated Ba can be built more efficiently. In relation to Ba, management must pay special attention to autonomy, creative chaos, redundancy and requisite variety as well as care, trust, love and commitment. These factors support the formation of Ba that gives energy and quality to socialization, externalization, combination and internalization. (Nonaka et al. 2001b, p. 34)

2.2.4. Knowledge assets

At the base of the knowledge creation process are knowledge assets. Nonaka et al. define these as firm-specific resources that are indispensable for creating value for the firm. Knowledge assets are the inputs, outputs and modifying factors of the knowledge creation process. Knowledge assets can be divided into four classes, as shown in Figure 20. This classification makes it easier to understand the creation, acquisition and exploitation of knowledge assets. The four types of knowledge assets are experiential knowledge assets, conceptual knowledge assets, systemic knowledge assets and routine knowledge assets. (Nonaka et al. 2001b, pp. 28-29)

Experiential Knowledge Assets	Conceptual Knowledge Assets
Tacit knowledge shared through common experiences •Skills and know-how of individuals •Care, love, trust and security •Energy, passion and tension	Explicit knowledge articulated through images, symbols and language •Product concepts •Design •Brand equity
Routine Knowledge Assets	**Systemic Knowledge Assets**
Tacit knowledge routinised and embedded in actions and practices •Know-how in daily operations •Organizational routines •Organizational culture	Systemised and packaged explicit knowledge •Documents, specifications, manuals •Database •Patents and licenses

Figure 20. Four categories of knowledge assets (Nonaka et al. 2001a, p. 29).

Experiential knowledge assets include shared tacit knowledge that has been formed in the interaction amongst the members of the organization and outside groups. As an example, Nonaka et al. mention skills and know-how that have been accumulated through experiences at work. Emotional knowledge also belongs in experiential knowledge assets. It is hard to grasp, evaluate and sell off experiential knowledge assets. This is caused by the tacit nature of the knowledge involved. (Nonaka et al. 2001b, pp. 29-30)

Conceptual knowledge assets include explicit knowledge articulated with the help of images, symbols and language. These knowledge assets are based on the concepts possessed by members of the organization and customers. As examples, Nonaka et al. mention the brand equity perceived by customers and the concepts or designs perceived by members of the organization. It is easier to grasp conceptual knowledge assets due to their tangible forms. (Nonaka et al. 2001b, p. 30)

Systemic knowledge assets are the most visible of all knowledge assets. They consist of systematized and packaged explicit knowledge, such as technologies stated in explicit form, product specifications and manuals. Documented and packaged information about customers and suppliers also belong here. Legally protected intellectual properties, such as licenses and

patents, can also be considered a part of systemic knowledge assets. These knowledge assets can be transferred relatively easily. (Nonaka et al. 2001b, p. 30)

Routine knowledge assets consist of tacit knowledge embedded in actions and practices of the organization. They are characterized by their practical nature. As examples, Nonaka et al. mention know-how, organizational culture and organizational routines. As a consequence of continuous practice, certain patterns of thinking and action are reinforced and shared amongst the members of the organization. Sharing the background of the company and stories about the company helps the formation of routine knowledge. (Nonaka et al. 2001b, p. 30)

2.2.5. Knowledge-creating process

The organizational process of knowledge creation presented by Nonaka and Takeuchi consists of five phases: the sharing of tacit knowledge, creation of concepts, justification of concepts, building of models and dissemination of knowledge. This model combines the modes of knowledge conversion with the enabling conditions for the knowledge spiral. (Nonaka & Takeuchi 1995, pp. 83-84) The model describing the knowledge-creating process is presented in Figure 21.

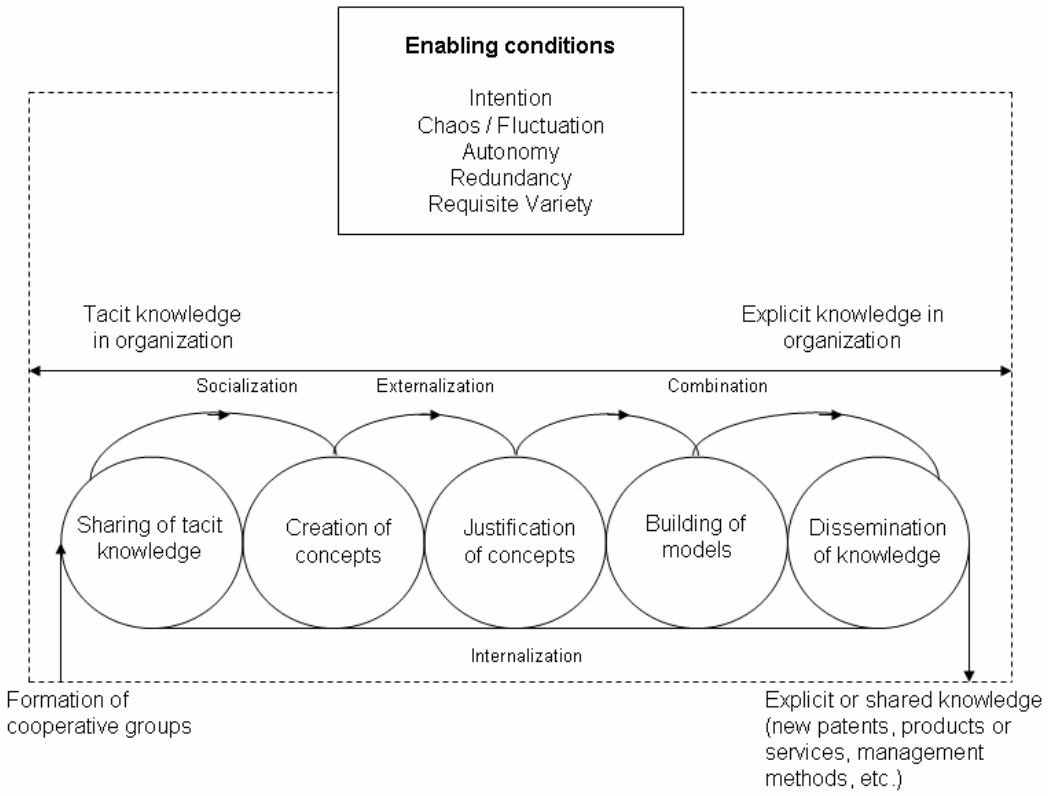

Figure 21. Knowledge-creating process (adapted from Ruohotie 2000, p. 268).

According to Nonaka and Takeuchi, the organizational process of knowledge creation starts with the sharing of tacit knowledge possessed by individuals. This rich and unused source of new knowledge is a natural way of triggering the process of knowledge creation. Sharing tacit knowledge is not easy, as the knowledge has been mainly acquired through experience and therefore is not easily transformed into written form. The sharing of tacit knowledge with people from different backgrounds and viewpoints is an important step for knowledge creation. In order to generate a mutual feeling of trust, individuals must share their feelings and thinking models. This requires interpersonal face-to-face interaction. Typically, this kind of interaction is possible through self-organizing teams. These teams consist of members coming from a variety of functional departments, who are working together to reach a shared goal. Self-organizing teams of this type enable the process of organizational knowledge creation through the requisite variety brought by the members. The members experience redundancy of information and share their own interpretations on the intention of the organization. The management generates creative chaos by setting challenging goals and giving team members an opportunity to act autonomously. (Nonaka & Takeuchi 1995, p. 85)

The second phase of the process of knowledge creation is the most intensive phase of the interaction between tacit and explicit knowledge. Shared, tacit thinking models are put into words and phrases. Finally, they are crystallized into explicit concepts. Nonaka and Takeuchi note that in this sense the second phase of the organizational process of knowledge creation corresponds to externalization. When concepts are created, the use of analogy and metaphors helps to root a creative way of thinking in the organization. The concepts are created in cooperation through dialogue. Autonomy helps team members to think freely. Intention shows the way for members to think. When concepts are created, team members must consider the existing starting points in a thorough way. In this sense, requisite variety offers different viewpoints on the problem. Internal or external fluctuation and chaos also helps team members to change their way of thinking. Redundancy also helps members to understand the descriptive use of language and to crystallize shared thinking models. (Nonaka & Takeuchi 1995, pp. 85-86)

In the third phase of the process of knowledge creation, the new concepts developed by individuals or teams must be justified. In the process of justifying concepts, it is decided whether the newly developed concepts are useful from the viewpoint of the organization and the community. Individuals justify or prune information, concepts and knowledge throughout the process. However, the organization must carry out this justification in a more explicit way to ensure that the intention of the organization is in line with the concepts developed. The

organization must also ensure that the concepts correspond generally to the community's needs. According to Nonaka and Takeuchi, the normal criteria for justification in business organizations consist of costs, profits and the evaluation of how the product affects the growth of the business. The justification criteria can be both quantitative and qualitative. It is the task of top management to define the criteria in the form of the organization's purposefulness. This is expressed in the form of a strategy or a vision. To prevent misunderstandings of the company's intention, redundancy of information helps to promote this process of justification. (Nonaka & Takeuchi 1995, pp. 86-87)

In the fourth phase of the process of knowledge creation, the justified concept is converted into the form of a concrete model. The building of models concerns the combination of new and existing explicit knowledge. Nonaka and Takeuchi note that for this reason, the fourth phase of the process of knowledge creation resembles combination. They also state that because this phase is a complex one, cooperation between different departments of the organization is necessary. Requisite variety and redundancy of information make this process possible. The intention of the organization combines together the different kinds of know-how and technology found within the organization. It also promotes cooperation between people and departments. In this phase of the process of knowledge creation, autonomy and fluctuation do not play such a significant role. (Nonaka & Takeuchi 1995, pp. 87-88)

Once the new concept has been created, justified and modelled, it moves to a different ontological level. The process of knowledge creation is endless and refines itself all the time. This interactive, spiral-like process, which Nonaka and Takeuchi call "networking knowledge", occurs within the organization and also between organizations. Knowledge which has become real or has been modelled can trigger a new cycle of knowledge creation by expanding both horizontally and vertically throughout the organization. Through dynamic interaction, knowledge created by an organization can trigger knowledge creation in affiliated companies, customers, suppliers, competitors or other outside parties. In order to enable this phase to function efficiently, it is vital for all units of the organization to have the autonomy to adapt knowledge developed elsewhere and to utilize it freely over boundaries and levels. The dissemination of knowledge is enabled by internal fluctuation, such as the continuous rotation of personnel to different tasks. The dissemination of knowledge is also affected by redundancy of information and requisite variety. In relation to the dissemination of information within the organization, the intention of the organization determines whether the knowledge created should be redistributed within the company. (Nonaka & Takeuchi 1995, pp. 88-89)

2.2.6. Key findings for ontology building

The process of knowledge creation presented above should be examined holistically. All modes of knowledge conversion must be supported. This research aims to develop an assessment system that examines the knowledge creation activities of organizations. The aim is to further the realization of the different phases of the knowledge spiral.

In this research, Nonaka and Takeuchi's (1995) theory of organizational knowledge creation is used when analysing different concepts and activities supporting the modes of knowledge conversion (Figure 22). The various concepts and activities were selected based on a literature review.

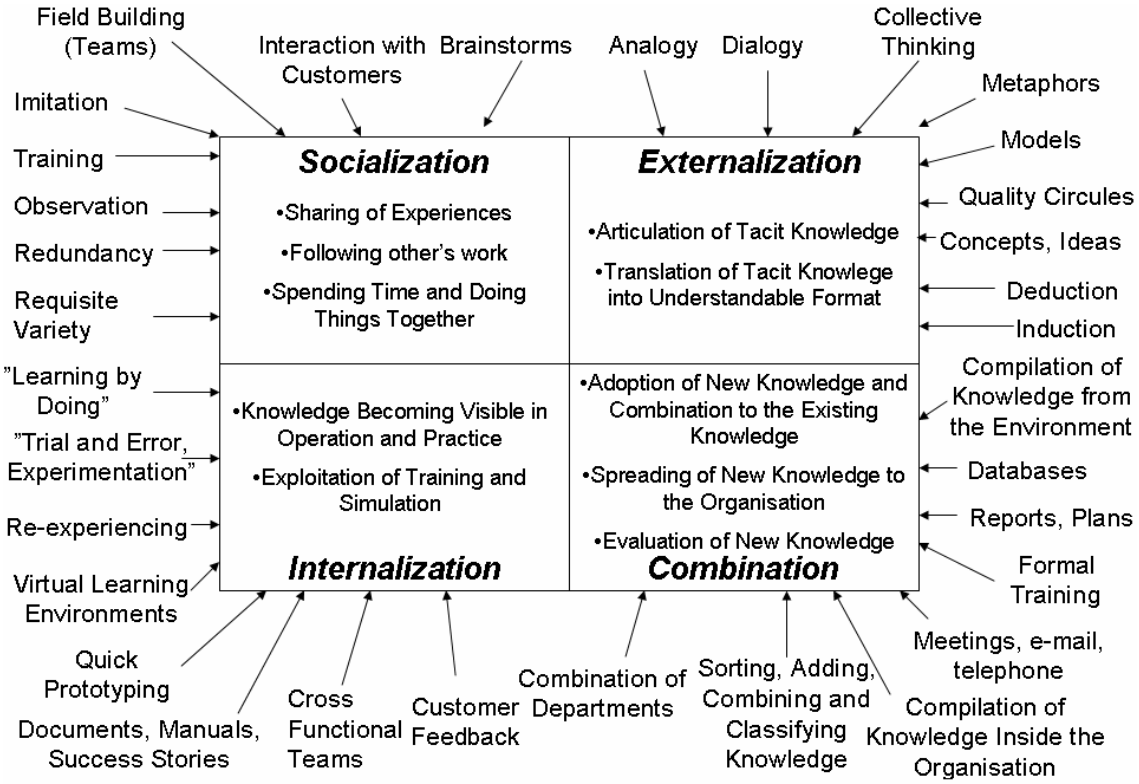

Figure 22. Modes of knowledge conversion (Paajanen 2006; cf. Nonaka & Takeuchi 1995).

The four modes of knowledge conversion form the basic structure of the ontology for knowledge creation. Knowledge creation can be seen as a management object that is easier to manage and develop when the concepts of knowledge creation are known by the members of the organization.

2.3. Organizations as living systems

According to Pawlowski (2001), organizations that have to cope with environmental complexity have to generate structures that can deal with complexity. In this research, organizations are seen as comprehensive living systems, which have the ability to change and develop their own functions.

2.3.1. Definition of systems

According to Davis (2003, p. 352), systems can be abstract or physical. It is also possible to define a system as a group of elements or objects, the relationships among them, their attributes and boundaries, which define whether an element is inside or outside the system. Boundaries separate systems from the environment or other systems. (Bennet & Bennet 2004, p. 277) Systems can also be divided to open systems and closed systems. An organization can be seen as an example of an open system, which necessarily has a high degree of interaction with its environment. (Campbell & Craig 2005, p. 17) Open systems exchange information, material, or energy with the environment. Biological systems are also open systems. (Davis 2003, p. 354) Figure 23 presents the three stages of the open system.

Figure 23. The three stages of the open system (Campbell & Craig 2005, p. 17).

Open systems continue their existence with a form and structure which allow them to adapt to changes in their environment (Davis 2003, p. 354). Systems which do not interact with their external environment can be termed closed systems. In these kinds of systems, all inputs and outputs are contained within the system. (Olson 2006, p. 95) Closed systems do not exchange material, information, or energy with their environment. Therefore, closed systems do not exist in organizations and information processing. (Davis 2003, p. 354)

Systems can also be static or dynamic. A system is static if it does not change with time. A system can be part of a larger system and have smaller systems within itself. These kinds of smaller systems are called subsystems. A system is a feedback system if the outputs of the system also become inputs to the same system. This is the case in most real systems. (Olson 2006, pp. 94-95) Organizations as systems contain many causal relationships within them.

Causal relationships may be positive, reinforcing feedback loops or negative, balancing feedback loops. (Bennet & Bennet 2004, p. 278)

2.3.2. Systems approach and systems thinking

The systems approach can be seen as an analytical and management approach in the development of organization systems. It is based on the concept of systems and it guides the process how systems are analysed, developed, combined into larger systems, implemented, enhanced and renewed. (Davis 2003, pp. 352-353) Systems theories view the organization as a total system and take into account a more holistic context both inside and outside the organization. The systems understanding of organizations has its origin in the analogy between the biological body and the corporate body. According to Campbell and Craig, this was noticed by the biologist Ludwig von Bertalanffy in his general systems theory. (Campbell & Craig 2005, pp. 17-18)

According to Von Bertalanffy (1972, p. 424), the general systems theory is a model of certain general aspects of reality and also a way of seeing things which were previously overlooked or bypassed. Bennet and Bennet (2004, p. 275) state that "while only moderately successful, the general systems theory was able to identify many insights and observations that help understand how systems work". Miller and Rise, who are also biologists, developed the general systems theory further. They linked corporate bodies to biological organisms. (Campbell & Craig 2005, p. 18)

Miller's (1978) living systems thinking analyses the structure and process of the seven hierarchical levels (cell, organ, organism, group, organization, society and supranational system) of living systems. Each level has 19 subsystems which process inputs, throughputs and outputs of various forms of matter, energy and information. Based on living systems thinking, Samuelson (1978; 1981) has presented a model of the living system's behaviour (Figure 24).

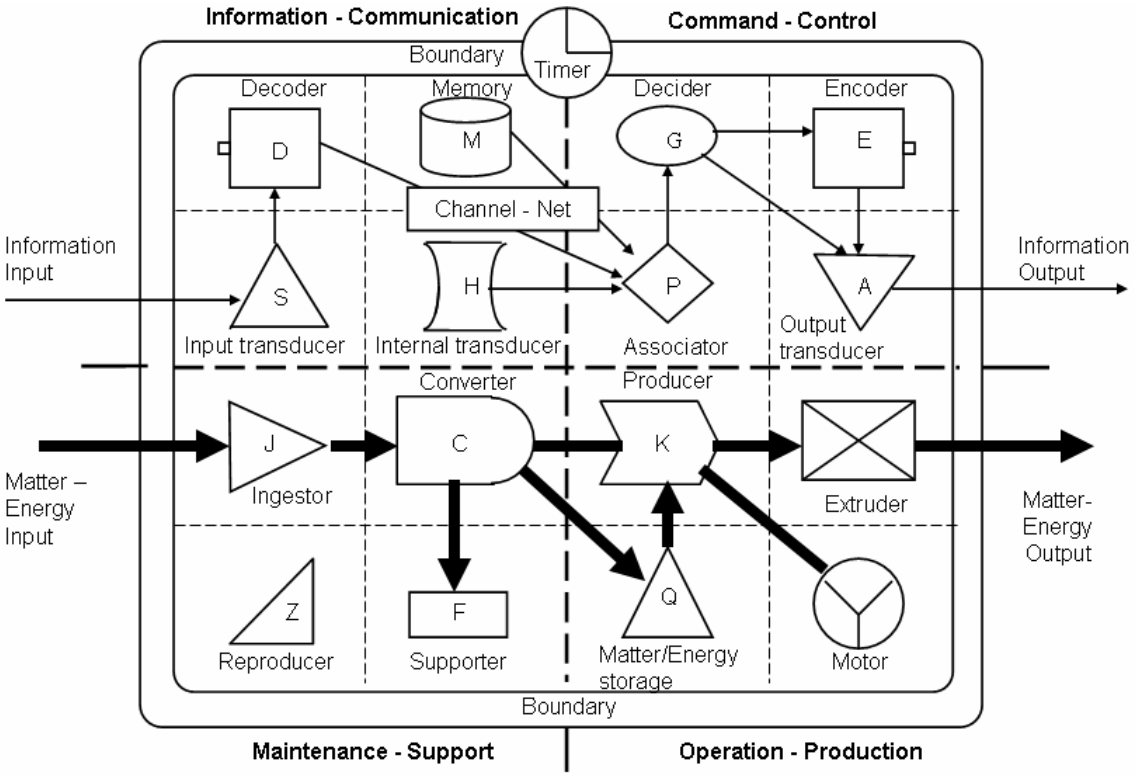

Figure 24. The living system and subsystem functions (adapted from Samuelson 1981, p. 221; Österlund 1994, p. 23).

In Figure 24, which is reconstructed by Österlund (1994), the left upper section consists of the functions dealing with the living system's information and communication. The right side of the upper section consists of the functions dealing with the living system's command and control. The left side of the lower section consists of the functions dealing with the living system's maintenance and support. In turn, the right side of the lower section consists of the functions dealing with the living system's operation and production. Together, these four sections also form the general concepts of organizational management: keeping and maintaining a functioning system.

There is also a difference between the soft systems approach and the hard systems approach. Hard systems modelling assumes the existence of well-defined objectives and rational behaviour by human participants in achieving the objectives. On the contrary, the soft systems approach focuses on the existence of purposeful action in human affairs and it employs various methods and mechanisms to clarify the worldviews of the participants and build consensus. The soft systems approach also supports a social process in which a group of people in a particular organizational context define the purposeful action to be taken. (Davis 2003, pp. 357-358)

Checkland and Poulter have presented their soft systems methodology (SSM), which is an approach used for tackling problematical and messy situations of all kinds. They define soft systems methodology as follows: "SSM is an action-oriented process of inquiry into problematical situations in the everyday world; users learn their way from finding out about the situation to defining/taking action to improve it. The learning emerges via an organized process in which the real situation is explored, using as intellectual devices - which serve to provide structure to discussion - models of purposeful activity built to encapsulate pure, stated worldviews". (Checkland & Poulter 2010, p. 199)

According to Iba (2010, p. 6611), problems today are quite complex and dynamic to solve and therefore it is important to gather creative abilities beyond individual professions and disciplines. The complexity in a system is a result of the interaction of system variables over time (Schneider & Somers 2006, p. 360). Systems thinking is a conceptual framework that has been developed over the past 50 years to make the structure of systems and patterns of change clearer. Systems thinking helps to understand system behaviour and solve problems more effectively. (Bennet & Bennet 2004, p. 275)

Systems thinking can be seen as a new way to see the world. Systems thinking is able to broaden an individual’s perspective and help understand what systems are and how they work. Systems thinking can be used to model a system. This helps in understanding the key forces and the effect of the major relationships within the system. With the help of systems thinking it is possible to better understand the environment. It allows us to see our own work as it relates to the larger organization. It also guides decisions for improving operational effectiveness in a complex world. (Bennet & Bennet 2004, pp. 275-276)

According to Schiuma et al. (2012, p. 8046) systems thinking is encompassed by different methodologies and tools, which are aimed at disclosing the relationships characterizing a system. Systems thinking as an idea permeates both popular culture and numerous scientific fields. These include planning and evaluation, education, business and management, public health, sociology and psychology, cognitive science, human development, agriculture, sustainability, environmental sciences, ecology and biology, earth sciences, and other physical sciences. (Cabrera et al. 2008, p. 299) Olson (2006, p.112) states that the philosophy behind systems thinking is that it is a learning process.

Systems thinking is also important for a knowledge management framework. Systems thinking facilitates the linkage between knowledge management initiatives and the strategic goals and objectives of an organization. With the

help of systems thinking, an overall view of the organization is obtained and this helps in maintaining a clear vision of what is being done and why it is being done. (Rubenstein-Montano et al. 2001, p. 12)

2.3.3. Key findings for ontology building

In this research, organizations are seen as open and dynamic systems. Organizations have the ability to change with the help of processes related to learning and knowledge creation. In this case, social processes have an important role and organizations are also seen as soft systems. In this research, living systems thinking has been applied in developing a responsive environment for organizational learning and knowledge creation. Learning takes place inside the boundaries of the organization. Different functions and activities are maintained with the help of four maintaining systems: control systems, working systems, information systems and support systems. Based on a literature review 26 maintaining system's features were identified and divided into different sections of maintaining systems. These features include different concepts and activities which can be used in maintaining an organization's learning and knowledge creation within the boundaries of a given system. This new framework for a responsive environment for learning and knowledge creation is presented in Figure 25.

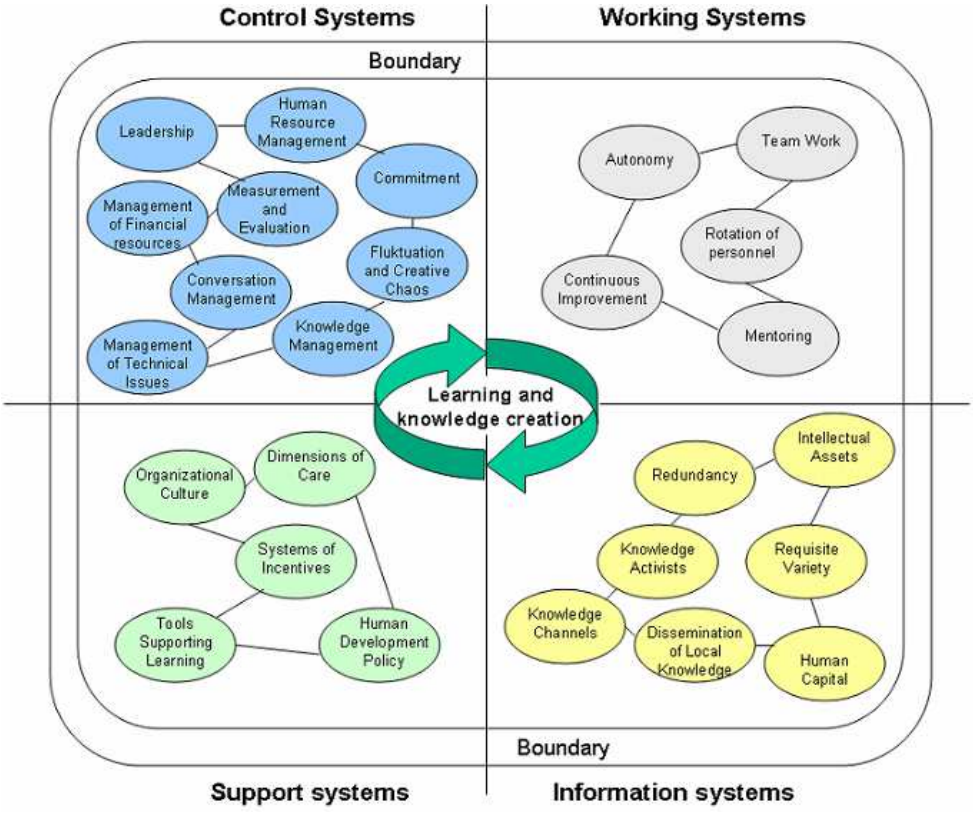

Figure 25. A responsive environment for learning and knowledge creation *(Paajanen 2006; cf. Samuelson 1981; Österlund 1994).*

This framework can help managers in planning development activities. The framework provides tools and concepts which can be used to start the development process. One sub-goal of this research is to build ontologies for learning and knowledge creation. Each ontology is actively maintained by these maintaining systems and their features. Maintaining systems and their features are defined in more detail below:

Control systems

Leadership aims to ensure the completion of work and work tasks with the help of skilled personnel. It is also essential to measure the results achieved and to assess them in relation to the goals that have been set. According to Ruohotie, leading people is not merely monitoring their efficiency and work attendance, but also directing, supporting and encouraging them. The members of a working community must have a clear view of the goals related to the organization's activity. They must also have sufficient resources to achieve these goals. A supervisor must also rely on the employees' ability to make decisions and ensure that they have the correct conception of their work, together with sufficient information to serve as the basis for the work. (Ruohotie 2000, pp. 45-46) According to Härkönen et al. (1993, p. 9), the role of supervisor is changing from a commander to a team leader and builder of preconditions as well as supporter of the group.

Instead of control, leadership is based on the following principles of modern management (Härkönen et al. 1993, p. 9):

- Principle of equality instead of supervisor/subordinate division.
- Principle of commitment instead of orders.
- Result-centredness instead of task-centredness.
- Principle of elbow room and freedom of action instead of work orders.
- Principle of feedback instead of surveillance.

Human resource management, according to Kauhanen (2000, p. 14), means the acquisition, motivation, maintenance, development and rewarding of an organization's human system. The personnel are viewed as a resource whose quality should always meet the current need and who should always be motivated to work towards the company's goals (Vanhala et al. 2002, p. 311).

Every organization should be able to attract the personnel it wants and to manage to keep them in the organization through motivation and incentives. In addition, organizations should have resources to develop their personnel in order to enable sufficiently high work performance. If goals are not met, this

may be caused by human resources being viewed as a cost factor or by management not considering the matter important enough. In an organization, lack of expertise in the efficient use of human resources will also prevent goals from being met. (Kauhanen 2000, p. 14)

Management of technical issues. Technology is viewed as an enabler in society and in the community. The management of technical issues is therefore vitally important for the success of companies. The utilization of technology is managed through people and with their help. Companies must offer to their personnel the tools and equipment necessary for carrying out the work efficiently. Among other things, these include computer hardware and software.

Management of financial resources requires that all activity in the business processes adds client value. All activity must therefore be understood as necessary, productive and profitable in at least some form. Companies and organizations must have sufficient financial resources to enable and support the learning of the personnel. For instance, learning can be supported by offering paid leave for training purposes and by spending money on high quality training programmes.

Conversation management. According to Von Krogh et al., conversations that include the mutual exchange of ideas, views and beliefs are what enables the first and most important phase of knowledge creation: the sharing of tacit knowledge. Conversation management does not affect merely the sharing of tacit knowledge, but also all the later phases of the knowledge-creating process. In business organizations, conversations usually have two main purposes. They either confirm the existence and content of knowledge or aim at the creation of new knowledge. Conversations which concentrate on the strengthening of knowledge are rather clear, as they concentrate on the present, facts and reality. The purpose of these conversations is mainly to reinforce explicit knowledge and the concepts used in the conversations already exist and are justified. These kinds of conversations reinforce and re-reinforce the stated expertise and allow efficient problem solving. (Von Krogh et al. 2000, pp. 125-126, 128)

Von Krogh et al. have noted that when new knowledge is being created, there are no uncontroversial facts or explicit models to show whether the participant in the conversation is right or wrong. The participants do not just intend to create new knowledge. Their aim is to build a new reality. In that case the focus is on the future and conversations are directly tied to the company’s knowledge vision. The scope and effect of the matters discussed is in principle unlimited right from the start. (Von Krogh et al. 2000, p. 128)

In the different phases of the knowledge spiral presented in Chapter 2.2.2, interpersonal conversation is central to the creation of new knowledge. In the socialization phase, tacit knowledge can be created through the sharing of experiences. In the externalization phase, people try to conceptualise their mental images with speech. In the combination phase, individuals exchange and combine knowledge, for instance in phone conversations. Internalization is helped by the telling of success stories, which enable people to “re-experience” the experiences of others.

Von Krogh et al. present four guiding principles for good conversations. These are active encouragement to participation, preparation of conversational etiquette, appropriate editing of conversations and fostering the use of innovative language. The different phases of the knowledge-creating process require different forms of conversation management. These four guiding principles have a larger or smaller role in the different phases of knowledge creation. (Von Krogh et al. 2000, pp. 131-138)

Managers can promote creativity in the company by ensuring wide participation in conversations. To free this potential, one must get people to converse and give them a good reason to carry on the conversation. The first task of the conversation manager is to create open doors for anyone who should participate. The managers can open the door for conversations in at least two ways. Firstly, they can encourage participation by making it clear why knowledge is being created. Secondly, they can ensure that the rituals of participation in conversations are even-handed and relatively easy to understand. Sometimes the rituals of conversation are rather closed. This may hinder the participation of newcomers, for instance in product development groups. The manager is responsible for changing the rituals in order to encourage participation in conversations. (Von Krogh et al. 2000, pp. 133-134)

In order to make knowledge-creating conversations pleasant and memorable, the right rules and etiquette related to conversations are needed. Excessive chaos in intra-group relationships is not a good thing. At the very least, all participants in the conversation should share the goal of knowledge creation and all the inputs of the various participants should be combined together. Knowledge-creating conversations should trigger other conversations later. For this reason, they do not depend on what is said but on how it is said. Von Krogh et al. present rules which are essential for knowledge-creating conversations. These rules are (Von Krogh et al. 2000, pp. 134-135):

- Avoid needless ambiguity.
- Avoid threats.

- Avoid using authority.
- Avoid ending the conversation prematurely.
- Be brief.
- Help other participants to be brave.
- Do not knowingly make false claims.

Knowledge-creating conversations have to do with tacit knowledge. It may be hard to select specific topics for conversations, as the tacit knowledge possessed by individual participants is tied to their own physical experiences and feelings. When several concepts of varying quality have been created as a result of a knowledge-creating conversation, the concepts with the greatest potential should be selected. The conversation may start from interpersonal discussions related to various personal experiences, but as it progresses, the expressions should crystallize into one or a few concepts that receive attention from the group. (Von Krogh et al. 2000, pp. 135-136)

Crystallization can usually happen in one of two ways: agreement or understanding. In practice, both of these are reached simultaneously. When participants of a conversation agree on a given expression or concept, it is assumed at the same time that they really understand it. Group dynamics, participant uncertainty and the effect of dominant persons may force agreement even in situations where all participants do not yet have full understanding of a given concept. Understanding cannot be reached until all participants agree that an expression or concept corresponds to the tacit knowledge they have personally. Management must edit the right parts of the conversation at the right time. In the early phase of the knowledge-creating process, excessive cutting short of conversations may cause them to end. In the other phases of the knowledge-creating process, suitable cutting may help to maintain the conversation. (Von Krogh et al. 2000, pp. 136-137)

Language is a tool used by people to express their observations on the world. These observations are needed in the creation of new knowledge. Language must be exceptionally dynamic during the process of knowledge creation in order to enable the birth of innovative concepts. The promotion of innovative language use in creative conversations helps to give meanings to concepts and terms. Innovative language gives stimuli to new terms that are included in existing meanings, but also to new terms and entirely new meanings. (Von Krogh et al. 2000, p. 138)

Knowledge management is a process used to create, acquire, store, share and apply knowledge. According to Sydänmaanlakka, the aforementioned activities are sub-processes of knowledge management, which are used to

support the conversion of tacit knowledge into an explicit form and transform individual knowledge into group knowledge. The creation of new knowledge can occur, for instance, as a result of individual study, group thinking, activity in a cross-functional group and rotation of tasks. Knowledge can be acquired for instance from within the organization, from other organizations and from universities. (Sydänmaanlakka 2001, p. 172) According to Sadler, organizations must acquire and store knowledge that can be used by individual members of the organization. Organizations must also use this knowledge to improve performance. This process refers to knowledge management. (Sadler 2001, pp. 416-417) The acquisition of knowledge also involves the conversion of tacit knowledge into an explicit form and the documentation of knowledge in a form that enables transmission to others. In knowledge companies, active and independent acquisition of knowledge belongs to everyone. (Sydänmaanlakka 2001, p. 172)

Acquired or self-created knowledge must be put in such a form that it is easily accessible by everyone. Knowledge must be processed, structured and edited so that the organization's databases are logically organized, reliable and precise. On the individual level, this means reflecting on what is experienced and internalizing it. In organizations, knowledge is stored among other things in documents, minutes, memos, manuals and instructions. Sydänmaanlakka states that knowledge must be easily accessible by anyone. Storing knowledge well is a precondition for sharing it efficiently. The dissemination of knowledge also requires a culture that encourages the sharing of knowledge and the exchange of thoughts, ideas and methods. From the viewpoint of sharing knowledge, good information systems are an efficient tool. Personal contacts and informal networks also have their significance. The application of the knowledge determines the benefit to the organization. Organizations typically make use of only a small part of the knowledge inside the organization. The problem may be that people want to develop solutions of their own instead of using already existing knowledge. The easy availability of knowledge makes it more likely that the knowledge will be used. (Sydänmaanlakka 2001, pp. 173-174)

Fluctuation and creative chaos stimulate the interaction between the organization and its external environment (Nonaka & Takeuchi 1995, p. 78). According to Nonaka et al., fluctuation is characterized by order without recursivity, which is different from complete disorder. Among other things, fluctuation can be caused by changes in the market, the growth of competitors, and the challenges set by top management (Nonaka et al. 2001a, pp. 508-509). When an organization encounters fluctuation, its members encounter the "disintegration" of routines, methods and cognitive frameworks. This

disintegration interrupts the normal and pleasant state of the organization. Nonaka and Takeuchi see this as an opportunity to reconsider fundamental thinking and viewpoints. This way old attitudes towards the existing world can be questioned. A process of this kind requires deep personal commitment by individuals. In social interaction, fluctuation requires the drawing of attention to dialogue, which helps in turn in the creation of new concepts. This is a continuous process where the questioning and rethinking of existing factors by organization members helps the creation of new knowledge in the organization. (Nonaka & Takeuchi 1995, pp. 78-79)

Chaos is generated naturally when the organization encounters a real crisis, such as a rapid decrease in performance due to market demand or significant growth by competitors (Nonaka & Takeuchi 1995, p. 79). According to Ruohotie (2000, p. 267), creative chaos does not however mean disorder as such. Chaos can also be created intentionally if the leaders of the organization attempt to evoke a sense of crisis amongst the members of the organization by proposing challenging goals. According to Nonaka and Takeuchi, intentionally created chaos can be called a creative chaos which increases the tension within the organization and focuses members' attention on defining the problem and resolving the crisis situation. This kind of approach is opposed to the information-processing model that points out a problem and finds a solution to it through a process of combining knowledge. (Nonaka & Takeuchi 1995, p. 79)

Nonaka and Takeuchi have noted that Japanese companies often resort to intentional unclarity and creative chaos. Senior management uses ambiguous visions and intentionally creates fluctuation in the organization. The benefits of creative chaos can be seen when organization members are able to assess their own activity. Without this assessment, fluctuation tends to lead to "destructive" chaos. Fluctuation in an organization may trigger a creative chaos that generates and reinforces the subjective commitment of individuals. Members of the organization do not encounter such situations regularly in their daily activities. (Nonaka & Takeuchi 1995, pp. 79-80)

Commitment. This means a personal commitment by the organization's leaders to learning and acting as examples to other members of the organization. According to Ruohotie (2000, p. 719), a self-developing manager is an irresistible example to subordinates. In the organization, different areas of competence, the organization's ability to learn, the management's readiness to support and direct learning, the transmission of knowledge, teamwork skills, and continuous development are being developed simultaneously. Ruohotie (2000, p. 67) has noted that commitment to the development of skills can be supported by developing skills at the individual, team and organization levels, by creating

incentive systems that inspire people to learn, and by developing structures and processes.

Measurement and evaluation. According to Vanhala et al., measurement can focus on different aspects of an object or on overall skills. Sometimes there is reason to measure critical knowledge or skill by itself. Examples can be patents, models or other knowledge entities that can be evaluated and counted. These also function sometimes as good indicators of the existence, level and type of a certain kind of skill. Sometimes, the persons themselves can be asked to assess their skills or the state of their unit. Outside assessors can also be used. Skills can also be evaluated through results that are connected to them more or less clearly. (Vanhala et al. 2002, p. 237) Tynjälä states that as a result of learning, the learners form their own conception of the matters studied and develop in their grasp of different skills. These learning results may vary from superficial memorization by rote to an in-depth understanding which appears as an ability to apply knowledge to the solution of practical problems or to a new way to conceive or illustrate a matter. (Tynjälä 1999, p. 18)

According to Moilanen (2001, pp. 21-22), measurement is important for the following reasons:

- Measurement forms the basis for systematic development.
- Measurement helps in the monitoring of goals and achieving of goals.
- Measurement helps in making visible the changes and learning in the organization.
- Measurement enables the division of changes and learning into smaller and more manageable parts.
- Measurement helps in building a shared basis for discussions.
- Measurement encourages individuals.
- Measurement makes the rewards and criteria for rewards in the organization more varied.

Through measurement, many things can be achieved of which the organization is not yet aware. Moilanen views measurement or evaluation as a rather important part of the whole from the viewpoint of learning organizations. Measurement can be used to develop structures and systems as well as human learning and skills. Follow-up information is also needed on these activities, because it is hard to keep up to date with the development of learning or a learning organization if these are not evaluated by some method. (Moilanen 2001, p. 22) The measurement process for learning and skills can be divided into four phases, as illustrated in Figure 26.

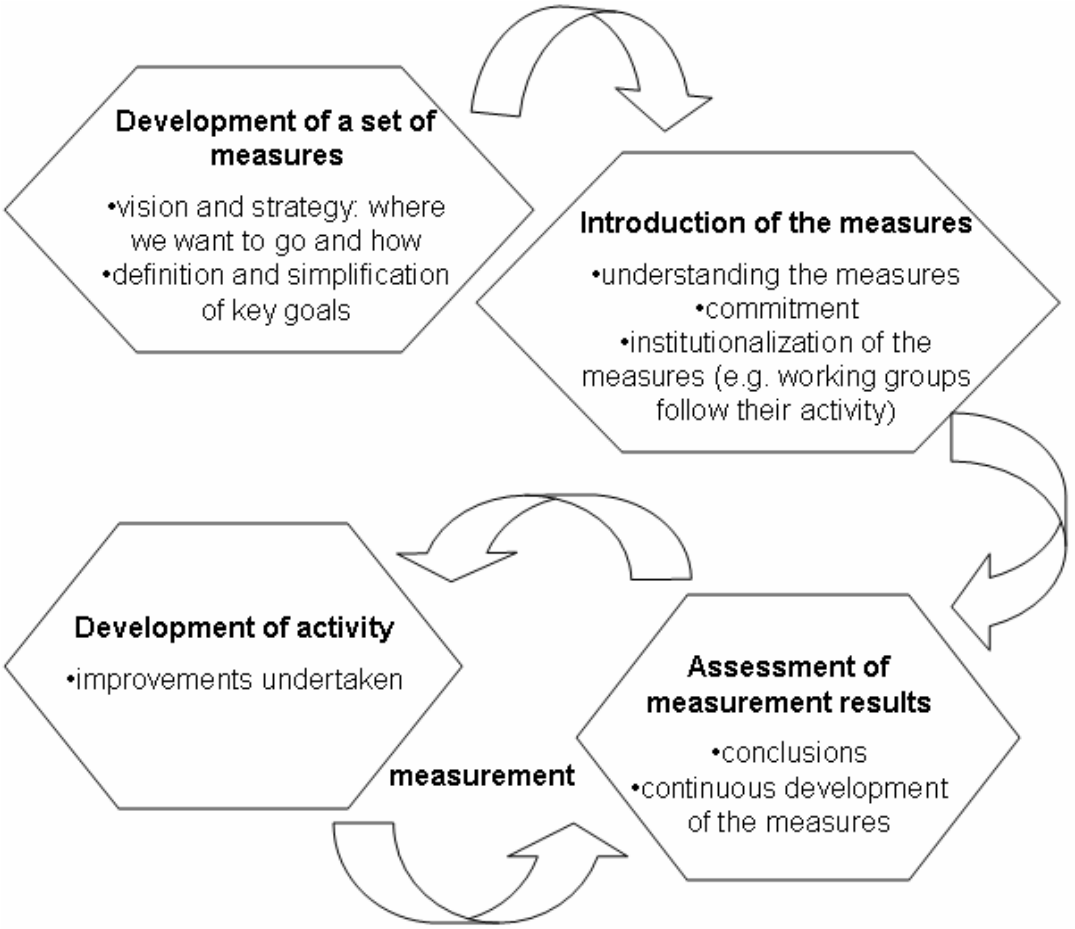

Figure 26. Building a set of measures for learning and skills (Ranki 1999, p. 49).

According to Ranki, measurement begins with the development of a set of measures. This is already a learning process by itself, as the challenge is to crystallize the key internal and external factors for the company. In measuring skills, it is simplest to measure not just know-how but especially activity, because skills are reflected in the activity. In the best case, employees view the measures as tools for development. Openness, however, is a precondition for this because employees must know what is being measured and why. Through measurement, it is possible to receive factual-based knowledge on the state of the skills and the direction in which they are developing. Measurement also gives feedback on the success of the various actions taken. (Ranki 1999, pp. 48-50)

Working systems

Autonomy. Nonaka and Takeuchi state that all members of an organization should act autonomously at the individual level as circumstances permit. Autonomy increases the possibility that individuals are motivated to create new knowledge. At the same time, unexpected opportunities are more likely to arise in the organization. Autonomously acting individuals function as part of a

holographic structure where the whole and all its parts share the same information. The original ideas come from autonomous individuals, are disseminated in groups and become a part of the organizational ideas. From the viewpoint of knowledge creation, this kind of organization is more likely to maintain flexibility in the acquisition and interpretation of information. Autonomous individuals and groups set their task boundaries for themselves in pursuit of goals expressed by a higher-level intention in the organization. In the business organization, self-organizing teams are a powerful tool for creating the kinds of circumstances where individuals can act autonomously. These kinds of teams should be cross-functional and cover the different functions in the organization. (Nonaka & Takeuchi 1995, pp. 75-76)

According to Juuti, autonomy requires a different organization of work than sharply delineated tasks. The organizational structure, management approach and organization of work must be in harmony with each other. Participation in the planning of goals and aims improves the employees' experiences that they have a chance to work independently and real opportunities to affect their own work. Unclarity about one's own role and goals is a significant stress factor. It is important for employees that they know the extent to which they can decide on matters related to their work. (Juuti 1989, p. 69, 98-99) In the organization, people must have the freedom to act and create and also independence in carrying out their work. On the other hand, the organization must maintain shared tasks and activities aiming at common goals. (Viitala 2003)

Peltonen and Ruohotie have noted that the concept of work autonomy is easily accompanied by the enrichment and expansion of work. In the enrichment of work, the role of employees in planning and supervision is increased. In the expansion of work, new functions are added to work tasks. For instance, work phases can be combined into larger wholes. To enable these actions to have positive results, it must be ensured that the employees are willing and able to carry out the new tasks. (Peltonen & Ruohotie 1991, pp. 107-108)

Teamwork. According to Ruohotie, different kinds of teams and groups have a crucial role in developing knowledge-creating organizations. Teams form a shared context where interpersonal interaction and dialogue takes place. Dialogues and discussions give new viewpoints, as they enable reflection and the combination of the knowledge possessed by individual team members. Establishing a team does not always automatically lead to positive results, but Ruohotie claims there is uncontroversial proof that the successful formation of teams will increase productivity and improve functional prerequisites in the organization. Teams are characterized by their task-oriented nature. Team members exchange information and resources, coordinate tasks and functions,

regulate requirements continuously and have an organization-like structure. Thus, team membership is task-related. (Ruohotie 2000, pp. 233-234)

At its best, teamwork is characterized by a spirit of continuous learning and experimentation that shakes up ossified attitudes and prunes disadvantageous routines. The efficiency of a team is clearly different from the efficiency of an individual. The performance potential of a team is based on factors at the individual level, such as the members' knowledge and skills, personality traits and status within the group. The size, structure, norms, cohesion and solidity of the group also affect the performance potential. In addition, the success of a team is affected by factors on the environmental level, such as the nature of the task, the stress caused by the environment, and incentives. Teams function as connectors between individuals and the organization. (Ruohotie 2000, pp. 233-234)

Rotation of personnel. This means the rotation of personnel to different work tasks at certain intervals, making their skills more varied. As a consequence of personnel rotation, knowledge moves quickly between different departments and good practices are spread to the whole organization. Rotation of personnel is also essential from the viewpoint of redundancy and requisite variety.

According to Lindeman-Valkonen, rotation of personnel is a systematic method of personnel development that can be used, for instance, to improve employees’ skills and motivation, build networks and exploit tacit knowledge. In addition rotation is a means of ensuring continuous learning in the organization and ensuring that the employees of the organization are skilful and able to work. To the employer, rotation of personnel is an important tool of personnel policy. It can be used to increase interest in the work and promote a positive image of the employer. (Lindeman-Valkonen 2001, pp. 7-8, 23) Varila (1992, p. 102) sees rotation rather as an economical means of increasing the competence of the personnel. Nevertheless, the renewed know-how and more wide-ranging views of the rotated employees may remain unused in the organization.

When it is implemented in the right way, rotation can be one of the most efficient methods for personnel development. One precondition is that the rotation is planned carefully, the goals are set clearly and the matters learned in rotation are successfully utilized by the organization after the rotation ends. (Lindeman-Valkonen 2001 p. 10) According to Ortega, rotation of personnel gives the organization information on how well different employees suit different tasks and it also shows how productive different tasks are. From the viewpoint of learning, rotation is more productive than specialization in a certain task. In addition, internal rotation of personnel is an important risk management tool.

(Ortega 2001, pp. 1361-1363) Frase-Blunt (2001, p. 47) notes that the spread of knowledge and skills through changing work tasks promotes the preservation of professional skill when employees resign, retire or are laid off.

The rotation of personnel between working groups is a good method for training personnel and increasing unified knowledge. Even a short-term rotation can have significant benefits. Employees see how their work affects others and how badly done work affects the whole. In addition, they are motivated to seek out ways of improving cooperation. (Frase-Blunt 2001, p. 48)

Mentoring is a very fast-reacting and real-time form of learning. According to Ruohotie, mentoring forms a fixed interactive relationship between mentor and protégé. Mentors are persons who commit themselves to supporting and helping either or both the professional and personal development of protégés. They increase the protégés' mobility to more demanding tasks. The relationship between mentor and protégé can be formal or informal. An informal relationship can be born without the organization being involved in any way. Formal relationships, on the other hand, are directed and sanctioned by the organization. (Ruohotie 2000, p. 222) Otala (2000, p. 254) regards mentoring relationships as very useful for the implementation of learning and for periods when the organization goes through violent change.

Continuous improvement. According to Salminen and Uitti, Kaizen or continuous improvement means constant and gradual improvement as opposed to innovation through large leaps. Continuous improvement concerns everyone in an organization. According to Kaizen, something should be improved in the company every day. Kaizen is a process-oriented way of thinking. By improving processes, the results will also get better. Kaizen can be considered as a problem-solving process. When a problem appears, it is eliminated by identifying its cause and removing it. In Kaizen, activity is developed in cooperation with all parts of the organization. As a consequence, a good communication network is required between different functions and departments to enable the company's goals and achievements to be known immediately everywhere. (Salminen & Uitti 1997, p. 89, 93)

Slack et al. state that the important thing about continuous improvement is not the speed of the change but the making of the changes themselves. The size of the changes does not matter so much either, as long as some kind of change and improvement has occurred during the period examined. (Slack et al. 2001, p. 611) Activity is developed in small steps when the entire personnel of the company take part in development work. The starting point is the removal of unnecessary work and waste through small investments. Unnecessary work

and waste consist of all functions that do not produce added value for the client. (Larikka & Pohjasmäki 1995, p. 9)

According to Salminen and Uitti, continuous improvement produces two main benefits. Firstly, it enables the solving of problems considered important by the organization. Secondly, people are involved in development activity. The result is a quickly changing and constantly developing organization. According to the basic idea behind Kaizen, the company's activity is measured by processes, not results. In this way, the company's activity can be guided in the right direction. Often the effects of continuous improvement are only observed several years later. The achievements are also greater in this case. The most important thing is to emphasize change in the long term. Productivity should increase as the factors that affect it are improved. (Salminen & Uitti 1996, pp. 97-98)

Information systems

Redundancy makes it possible for the knowledge spiral to work organizationally. As a term, “redundancy” may sound negative due to some of its connotations, such as unnecessary repetition, waste or information overload. Nonaka and Takeuchi define redundancy as the existence of the kind of information that transcends the immediate functional need of the members of the organization. In business organizations, redundancy refers to the intentional overlapping of information about business activities, management responsibilities and the company as a whole. From the viewpoint of organizational knowledge creation, it is important that the concepts created by individuals and groups come to the consciousness of other individuals even when they do not need the concept immediately. Sharing redundant information promotes the sharing of tacit knowledge, because individuals can sense what others are trying to articulate. Redundancy speeds up the process of knowledge creation. Sharing redundant information also helps individuals to understand their role in the organization. In this way, redundancy affects the thinking and actions of individuals. Redundancy of information provides the organization with a self-control mechanism that takes care of moving the organization in a certain direction. (Nonaka & Takeuchi 1995, pp. 80-81)

According to Nonaka and Takeuchi (1995, p. 81), redundancy can be created in organizations in several different ways. One is the Rugby approach used in product development, in which the different phases of product development are overlapping. Redundancy can also be created in organizations by promoting internal competition. In some companies, product development teams are divided into separate, competing groups that develop different approaches to the same project. The product development team sees the project from different

viewpoints, while competing groups discuss the pros and cons of the different approaches. The final goal of this discussion is to gain a consensus on the best approach. (Nonaka et al. 2001a, p. 510)

Nonaka and Takeuchi also see the rotation of personnel as one way of creating redundancy. This helps the members of the organization to understand the business from different viewpoints and enables the use of organizational knowledge. At the same time, the rotation of personnel helps each employee to accumulate skills development and sources of information. Individuals' extra knowledge on the organization's different functions helps the organization to expand its ability to create knowledge. (Nonaka & Takeuchi 1995, p. 81)

Requisite variety. According to the law of requisite variety, presented by Ashby in his book *An Introduction to Cybernetics*, only multiplicity can destroy multiplicity (Ashby 1957, p. 207). According to Ruohotie (2000, p. 267), the internal multiplicity of an organization must be in harmony with the multiplicity found in the environment. This way, the organization can respond to the challenges set by the environment (Nonaka & Takeuchi 1995, p. 82).

Requisite variety can be enhanced by combining information differently, flexibly and quickly, and providing everyone with equal access to the information found throughout the organization. To maximize requisite variety, the organization should ensure that everyone has the fastest possible access to the broadest variety of necessary knowledge through the smallest number of steps. Members of the organization cannot interact on an equal basis if there are differences regarding access to information. This weakens the search for interpretations related to new information. (Nonaka & Takeuchi 1995, p. 82)

Nonaka and Takeuchi have noted that the development of a flat and flexible organizational structure, where different units are interlinked with an information network, is one way of dealing with the complexity of the environment. Another way of reacting quickly to unexpected changes in the environment is to maintain internal multiplicity through changing the organizational structure frequently. The continuous rotation of personnel also makes it possible for employees to acquire interdisciplinary knowledge. This makes it easier to deal with multifarious and unexpected changes in the environment. (Nonaka & Takeuchi 1995, p. 83)

Human capital means the expertise of employees, their knowledge, attitudes, experience and contacts. Human capital is something that the company cannot own. It is a moving force behind innovation and the renewal of the company. (Sydänmaanlakka 2001, pp. 196-198) According to Sullivan, part of the

knowledge and know-how in companies is the tacit knowledge of individuals, which appears as knowledge and know-how. This kind of knowledge may leave the company when employees change employers, retire or are laid off. Knowledge leaves the company along with them, regardless of whether the company buys it when it hires them or they have learned it while employed by the company. (Sullivan 2000, pp. 157-158)

Intellectual assets. Sullivan notes that companies create lasting value through knowledge creation and know-how. The part of created knowledge and know-how that is recorded in written form constitutes the intellectual assets of the company. Thus, the intellectual assets are the tacit knowledge possessed by individuals that is written down, for instance on paper, in electronic media, or on any other media. Intellectual assets consist of programmes, inventions, processes, databases, methodologies, documents, drawings and plans. Some of these intellectual assets are protected by law, such as patents, copyrights, trademarks and trade secrets. These can be referred to as intellectual property. (Sullivan 2000, pp. 17-18, 156)

According to Sullivan, companies own their intellectual assets even though they cannot own the human capital of individuals. Knowledge recorded in written form can be shared with others, discussed, improved and expanded. This kind of knowledge can easily be brought to the attention of decision-makers and used as the basis for decisions. Intellectual assets are the knowledge which companies can exploit and which they aim to develop. (Sullivan 2000, p. 158)

Dissemination of local knowledge. The globalization (in this research, “dissemination”) of local knowledge aims to spread knowledge organizationally. Von Krogh et al. note that local knowledge possessed by one unit should also lead to a competitive advantage in other local units. In each local unit, knowledge should increase the ability to exploit local business opportunities and avoid threats. Knowledge coming from the head office or another business unit should be mixed with local knowledge, existing practices and experiences. Editing knowledge is also important in order to justify the knowledge in accordance with local values. The dissemination of local knowledge is a process, which consists of three stages: triggering, packaging/dispatching and re-creating. (Von Krogh et al. 2000, p. 209, 212)

According to Von Krogh et al., the first stage in the dissemination of local knowledge is to trigger the process. This stage is started when an opportunity or need related to business is perceived. Assuming that a new product or technology developed in some unit or group of the company has potential in other parts of the organization, it is discovered where the knowledge can be

exploited through re-creation. A group or unit may also seek out innovations, technical solutions or data to make it easier to carry out local tasks. Thus, the creators of knowledge must become aware of its seekers and the other way around. The search for knowledge always incurs costs. It is therefore a challenge for the management to find cost-efficient means of triggering the process of exchanging knowledge. These may include paper or electronic notice boards, regular knowledge conferences and the use of knowledge activists. (Von Krogh et al. 2000, pp. 213-214)

The second stage in the dissemination of local knowledge consists of the packaging of the knowledge. Only knowledge in an explicit form can be dispatched. Tacit knowledge often remains with the local business unit unless the persons who possess it travel to the same place to which the explicit knowledge is dispatched. Packaging the knowledge is important for moving it over organizational boundaries. Von Krogh et al. define five tasks for managers which they should take into account when packaging knowledge. Firstly, the managers involved in dissemination of local knowledge must select the information to be packaged. Only the kind of explicit knowledge that has helped the local business unit to solve its tasks should be dispatched. In addition, extra knowledge can be packaged based on experience. The receiving unit must be capable of finding out the knowledge received. Secondly, the managers at the sending unit must decide the order in which the packages are dispatched. Thirdly, they should name local experts in relation to the knowledge dispatched. Even if the document dispatched is in an explicit form, tacit knowledge is also needed to understand the document in depth. Fourthly, the managers must decide how the knowledge is stored. Fifthly, they must develop a policy related to the exchange of knowledge. This policy should enable people to recognise the justifications related to the exchange process, the knowledge being exchanged, and the matters related to packaging and dispatching the knowledge. (Von Krogh 2000, pp. 217-219)

According to Von Krogh et al., the third and most important stage in the process is the re-creation of the dispatched knowledge on a local level. One view of this is that the process of re-creation should produce a copy of the original knowledge. This view may, however, encounter obstacles. For instance, some objects have unique characteristics that cannot be imitated. Some skills are also hard to imitate or transfer between units. It is also possible that the pride ensconced in engineers and creative workers makes it hard to re-create knowledge unless the product or technology is especially rare, individual, interesting or challenging. The re-creation of knowledge also requires improvisation on a local level to enable action according to the explicit knowledge dispatched. (Von Krogh et al. 2000, pp. 220-222)

Knowledge channels. As examples of different channels for the dissemination of knowledge, Sydänmaanlakka (2001, p. 173) mentions e-mail, paper reports, websites, invitations to meetings, and systems based on databases. Knowledge channels are used to guarantee everyone access to necessary knowledge. Knowledge channels can be used to increase redundancy by sharing knowledge that exceeds the functional need of the persons working in the organization. The creation of new knowledge is also supported in this way. Knowledge channels also ensure that everyone is aware of the organization's aims and seek to fulfil the same goals.

Knowledge mediators or "knowledge activists" have an important role in at least four phases of knowledge creation. Von Krogh et al. write that knowledge activists form small communities of knowledge at the beginning of the knowledge creation process. Knowledge activists smoothen the creation and justification of concepts and also the building of models. Knowledge activists have an important role in the networking of knowledge, as they are responsible for triggering and combining the entire company's aims to acquire knowledge. Knowledge activists help groups to create enabling contexts, even though they do not directly participate in the sharing of tacit knowledge in groups. These kinds of contexts offer space and interactive relations for the dissemination of tacit knowledge. Knowledge activism may also be the responsibility of a given department or person. (Von Krogh et al. 2000, p. 148)

Von Krogh et al. define three possible roles for knowledge activists. These roles are catalysts of knowledge creation, connectors of knowledge creation initiatives and merchants of foresight. In the role of catalysts of knowledge creation, knowledge activists have two tasks. First, as the knowledge activists travel freely around in the company and talk to people from different organizational levels, they are exposed to a variety of knowledge, ideas, insights, opportunities, questions and problems. They can pick up on these signals and gradually formulate necessary "process triggers". The second task for knowledge activists as catalysts of knowledge creation is to create a context for knowledge creation (cf. Ba). Knowledge creation is strongly tied to the participants' personal experiences – both spoken and unspoken. For this reason, knowledge cannot be separated from its context. Knowledge is part of the physical, mental or virtual place where it is created. (Von Krogh et al. 2000, pp. 150-151)

Large- and medium-sized companies run several knowledge-creating activities simultaneously. In knowledge creating companies, a special emphasis is placed on actively connecting local initiatives. There is a possibility that one department develops a new concept, which has great similarities to a concept developed

previously in another department or even in another country. According to Von Krogh et al., the justification of a concept may have created negative experiences in the department that developed the concept originally. Even though the grounds for justifying a concept might have changed over time, these must be brought to the attention of the department currently developing the concept. To facilitate these connections is the task of the knowledge activist. (Von Krogh et al. 2000, pp. 152-153) The knowledge mediator is responsible for ensuring that those and only those parties in the organization for whom the knowledge is intended will receive the knowledge unaltered and without delay (Aula 2000, pp. 46-47).

Knowledge activists provide knowledge-creating groups with overall direction. In the role of a merchant of foresight, a good knowledge activist maintains the viewpoint of the micro-community, and at the same time takes care of the scale of a larger vision. In this role, knowledge activists are responsible for the participation of each micro-community in the development of the company. Knowledge activists must also detect how the different initiatives could change strategic posture. Knowledge activists must also demonstrate that the company's vision really focuses on knowledge creation and that the efforts of different micro-communities are of value. (Von Krogh et al. 2000, pp. 157-158)

Support systems

Organizational culture. Culture is the end result of organizational learning, but at the same time it also restricts such learning, as well as other organizational activities (Friedman et al. 2001, p. 760). According to Schein, managers create organizational cultures, which can be considered one of their most important management functions. If necessary, destroying a culture can also be important. Therefore it may be the case that the only really important task for managers is to create and manage culture. (Schein 1987, pp. 19-20) Otala (2000, p. 194) has noted the following features as characteristic for enterprise culture in learning organizations:

- Shared values, which are the moral code of the organization and create the basis for the culture.
- An open, positive culture that encourages experimentation.
- The organization tolerates mistakes and considers them a way to learn.
- Continuous questioning is the way to act.
- All individuals are the best experts in their fields.
- Everyone is committed to the culture of continuous improvement.
- Each process and team is guided by a customer-centred approach.
- The language of the organization reflects the culture.

The values form the moral code of the organization. They govern all activity and decision-making. Values cannot be given ready-made. Instead, an organization must live the values it selects for itself. The values start to live when management act as a role model, make decisions and act according to the values. People cannot be forced to adopt values. Everyone must commit to them personally. However, organizations can be steered towards values through rewards and criteria for measuring results. Individual and continuous learning are often included in the values of a learning organization. (Otala 2000, pp. 194-195)

According to Otala, an organization must have an open, honest and sufficiently safe atmosphere for people to withstand criticism and dare to take risks. Criticism and risk-taking are important factors in the self-renewal of organizations. In addition, the atmosphere must encourage people to try out new things, while mistakes are seen as a part of learning. When people learn from their mistakes, the same mistake will not be made again. If nobody makes mistakes in the organization, this suggests that nobody ever tries anything new. (Otala 2000, p. 195)

Otala sees the culture of continuous development as a starting point for the involvement of the entire personnel in the development of their own activities. In this case, everyone is the best expert in his or her field and for this reason the best person to develop his or her own activity. Learning starts from the willingness to develop one’s own work and one must never be satisfied with the level already achieved. In order to develop work, people must know the goals and what work and for whom it is to be developed. (Otala 2000, pp. 195-196)

In the organization, everyone must know the customers and compare the development activities taken with the added value produced for the customer. The organization must know the customers so well that it recognises the customers' needs before they do. All phases in the process of creating customer value are important. In this way, every employee of an organization affects customer satisfaction. When the customer is seen as a target of the entire activity, the whole becomes easier to understand. The language and terminology used by the organization also sends a message on the value of skills and learning. This also affects organizational culture. (Otala 2000, p. 197)

Dimensions of care. Von Krogh et al. state that when people encounter each other, some level of trust in the other is always generated. Trust compensates to some extent for deficient knowledge of the other, as for instance knowledge of the other’s motives, preferences, interests and background. Supporting the development of another person is not possible if it is not believed that this

person will utilize in the best possible way the teaching and suggestions given. Trust must also be mutual. A person can accept help offered if he or she believes in the good intentions of the one offering the help. (Von Krogh et al. 2000, pp. 49-50)

While trust forms the basis for care, empathy makes it possible to assess and understand what the other really needs. Von Krogh et al. believe that active empathy means an active attempt to understand other people. Caring about others take place through active questioning and observation. Through questioning, a deeper understanding of other's needs can be achieved. Thus, the deeper meanings in the background are understood, and others are helped to put into words the needs that are in the form of tacit knowledge. Empathy is important for receiving information on knowledge related to people's feelings. Acceptance of the emotional life of other people is essential in building good relations between employees. This in turn leads to efficient creation of knowledge. (Von Krogh et al. 2000, pp. 50-51) According to Ylikoski (1994, p. 68), emotional support also means the sharing of successes and setbacks with the work community. It is reflected in mutual care, acceptance and trust in the work community.

Empathy lays the groundwork for helping behaviour, but care must also be extended in the direction of actual assistance. The willingness to help must be combined with easy access to the helper. Von Krogh et al. note that, in companies whose context supports the creation of knowledge, help is available to all those who need it. Individual professionals have two responsibilities that must grow comparably. The first is the acquisition of knowledge. The second is how easily the professionals are accessible to those who need help. The more knowledge an individual has, the larger is the responsibility for helping others. Von Krogh et al. characterize as "caring experts" the members of the organization who reach a high level of personal mastery in relation to explicit and tacit knowledge and also understand their responsibility for sharing this process. Thus, all members of the organization must increase their consciousness of this role so that they can act as efficient teachers or tutors as their own skills increase. (Von Krogh et al. 2000, pp. 51-52) According to Ylikoski (1994, p. 68), informational support includes functional and unlimited access to knowledge.

While care is a general feature related to organizational relations, helping behaviour must be completed by gentle behaviour by organization members towards each other. In every company, individual employees sometimes act incompetently. In the words of Von Krogh et al., the assessment of this kind of incompetence is not possible on the basis of earlier rules and orders. From the

viewpoint of knowledge creation, there are only a few criteria for efficient activity. Participants in the knowledge creation process or observers of the concept or model created in this process are not capable of assessing whether people acted in the best possible way during the process. However, assessment is important for the development of individual and social knowledge. People assess their own experiences and actions as well as those of others. (Von Krogh et al. 2000, p. 53) Reinforcing support means encouraging and appreciative feedback in the work community and a responsible atmosphere where all members of the community are equal (Ylikoski 1994, p. 68). Harsh criticism may prevent the externalization of knowledge, which is used to create explicit knowledge. In the worst case it may extinguish the remaining phases of knowledge creation. (Von Krogh et al. 2000, p. 53)

According to Von Krogh et al., courage is important for organizations in three different ways. Firstly, people must be courageous enough to allow other group members or even themselves to try things out. Secondly, the persons participating in knowledge creation must be courageous when they present the concepts they have created for others to criticise. Thirdly, it takes courage to express one's own opinion or to give feedback as part of another person's development process. It requires great courage to give feedback, as the feedback can be negative or disturbing to the recipient. (Von Krogh et al. 2000, p. 54)

Systems of incentives. Vanhala et al. (2002, p. 333) observe that rewards have traditionally been perceived in companies in a rather narrow way. They have mainly consisted of wages, other comparable benefits and promotions. Sydänmaanlakka states that the incentivization and rewarding of personnel includes many other things as well. Wages are of course an important part of motivation, but it can also cause dissatisfaction if the employee does not view it as sufficient. Sufficient positive feedback helps maintain work satisfaction at work in the long term, as does the giving of training and development possibilities and sufficiently challenging tasks. The company's image and values together with a supportive atmosphere also motivate employees at work. (Sydänmaanlakka 2001, p. 110).

According to Ruohotie, incentive systems also support a learning culture. Rewarding learning from mistakes, assessment of learning processes and outcomes, encouragement of experimentation and the tying of bonuses to learning and expertise all help to develop a working environment favourable for learning. When supervisors are rewarded for anticipating required skills and applying strategies that further learning, these also create an important basis for

a learning culture in companies. In addition, it is important to divide the responsibilities so that no one has to fear any personal punishment for failures when trying out new things. (Ruohotie 2000, p. 68)

Human development policy must be clear and encourage everyone to develop. Clear rules are needed for funding, use of time, materials and other practical matters. If there are no clear rules, human development policy may remain on the level of broken promises and empty talk. Supervisors must be able to prepare rotation of tasks and learning situations at work. If necessary, they must also allocate resources to learning. Different financial means of support for study and training are part of the human development policy. (Otala 2000, pp. 250-251)

Tools supporting learning include learning guides, learning memos, personal development plans and study books. A learning guide clarifies the learning process of both individuals and teams. It also tells people how learning can be furthered. A learning guide includes instructions on the testing of one's own learning style, the interpretation of results, and the utilization of one's learning style when preparing one's own development plant. The guide can also include problem-solving techniques, instructions for benchmarking, questioning, constructive analysis of errors and the assessment of learning at work. (Otala 2000, p. 254)

Otala writes that a learning memo helps one to view learning as part of one's daily activities. The learning memo can record the key learning experiences of a day, a week or a specific event. It can be used to assess how the things learned can be applied in one's own work and to list things about which more information is needed. With a learning memo, daily events can be used to further learning in the best way. (Otala 2000, p. 255)

A personal development plan is used to record the training and learning programmes agreed with one's own supervisor. The plan also takes into account the targets related to one's work, the targets of one's team and one's personal aims. (Otala 2000, p. 255)

Study books are company-specific registers of the continuous learning of personnel. Individuals receive a mark in the study book when they have reached the level of each competence required. Otala states that the study credits marked in the study books can also be connected to official educational institutions, which makes the study books more official in nature. Study books can also be used to record the company's training and learning principles, the

training policy for personnel, values, ways of acting and the competence targets for the following years. (Otala 2000, pp. 257-258)

2.4. Management object ontologies

One goal of this research is to develop the content of ontologies that examine an organization's learning environment and knowledge creation activities. The following sub-chapters examine the definitions of ontologies and how ontologies are built.

2.4.1. Definitions of ontology

Corho et al. explain that the word ontology originates from philosophy, where it means a systematic explanation of being. Several definitions for ontologies can be found. Neches et al. (1991) defined ontology as follows: "an ontology defines the basic terms and relations comprising the vocabulary of a topic area as well as the rules for combining terms and relations to define extensions to the vocabulary." Corcho et al. have noted that according to this definition, ontology includes the terms that have been explicitly defined and also the knowledge that can be inferred from it. (Corcho et al. 2003, pp. 42-43)

In the words of Gruber (1993), ontology is "an explicit specification of a conceptualization". Borst (1997) changed this definition slightly and defined ontology as follows: "ontologies are defined as a formal specification of a shared conceptualization". Guarino et al. (1995) analysed seven definitions of ontologies and in their opinion, an ontology could be considered "a logical theory which gives an explicit, partial account of a conceptualization" In this definition, conceptualization is basically an idea of the world that a person or a group of people can have. (Corcho et al. 2003, p. 43)

Uschold and Jasper (1999) have given the following definition for ontology: "An ontology may take a variety of forms, but it will necessarily include a vocabulary of terms and some specification of their meaning." According to Corcho et al., these different definitions offer variable and complementary points of view of the same reality. Some of the definitions are independent of the process followed in building the ontology and also independent of its use in applications. However other definitions are influenced by the ontology development process. It is also characteristic of ontologies that they can be re-used and shared across applications and by different groups of people. Corcho et al. state that ontologies are usually built in co-operation by a group of people in different locations. (Corcho et al. 2003, p. 44)

Chandrasekaran et al. (1999, p. 22) found the following considerations in the general agreements related to the content of ontologies:

- The world contains objects.
- Objects have qualities and attributes that may have values.
- Objects may have different kinds of relations to each other.
- Qualities and relations may change over time.
- There are events at different points in time.
- There are processes in which the objects participate and which appear over time.
- The world and its objects may be in different states.
- Events may cause other events or states as a consequence.
- Objects may have parts.

According to Fensel (2001), an ontology produces an explicit concept that describes the semantics of the data. An ontology has the same function as a database system. However, they have the following differences:

- Ontology languages for defining ontology are syntactically and semantically richer than database approaches.
- Information described by an ontology includes half-parsed text of natural language. It does not include information in tabular form.
- An ontology is used to share and exchange information, so it must be a shared terminology based on consensus.
- An ontology produces a theory of its subject area. It does not produce a structure for the data content.

Fernández et al. have noted that the differences between ontologies and Knowledge Based Systems (KBS) may cause confusion. The latter are usually built incrementally using developing prototypes, where the end product may be used as a definition for the next prototype. The biggest difference is that ontologies are built to be re-used or shared at any time or place, regardless of the behaviour or subject area of the application using them. (Fernández et al. 1997, p. 33)

According to Hyvönen, ontologies differ in their purpose and mechanisms for presenting knowledge. Ontologies can also be classified accordingly, as in the following examples (Hyvönen 2002, pp. 14-15):

- Scientific ontologies, such as biology, electronics, etc.

- Business ontologies for the presentation of products, business models, etc.
- Cultural ontologies for the presentation of art, artefacts, etc.
- Collections of meta-knowledge, such as the meta-concepts used to describe the ontology itself.
- Ontologies of dynamic events, such as tasks, processes and services.

In this research ontologies are developed that are used to describe dynamic ontologies related to an organization's learning environment and knowledge creation. These ontologies also include collections of meta-knowledge, which describes the management systems required in developing and maintaining the organization's ability to learn and evolve.

2.4.2. Ontology building

According to Beck and Pinto, building an ontology is a process that usually comprises the following main phases: definition, conceptualization, formalization, realization and maintenance (Figure 27). The purpose and scope of the ontology are identified in the definition phase. In conceptualization, the conceptual model is described so that the definition that was made corresponds to the ontology. In formalization, the conceptual description is translated into a more formal shape. In realization, the formalized ontology is written in the language of the ontology. In maintenance, the realized ontology is updated and errors are corrected. The acquisition, documentation and assessment of knowledge are activities that should be done during every main phase. The re-use of an ontology is also an activity that should be done, but it depends on the methodology used. (Beck & Pinto 2002, pp. 22-23)

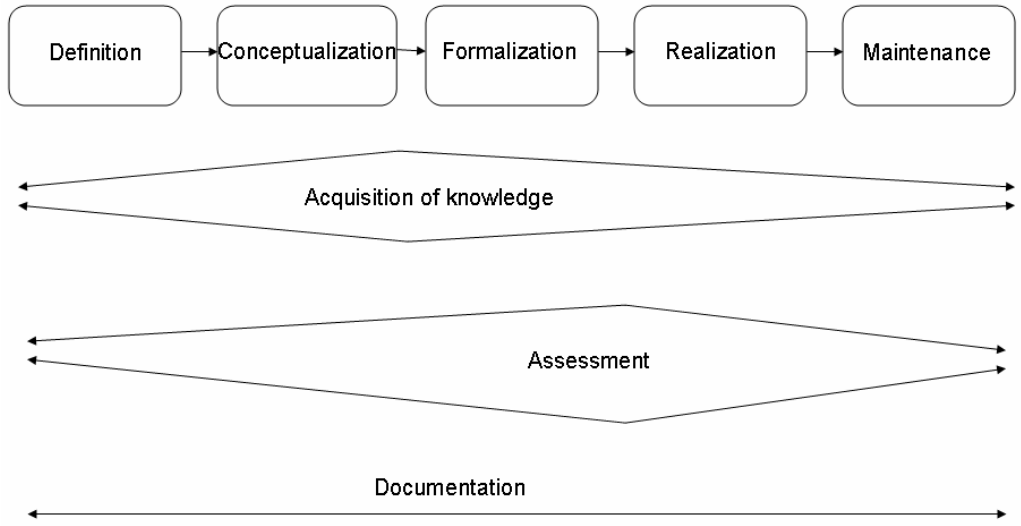

Figure 27. The activities of an ontology's development lifespan (adapted from Beck & Pinto 2002, p. 23; Mäki-Tanila 2006, p. 36).

Kantola defines organizational resources as Management Objects (MOs). These objects can be tangible or intangible. With ontologies, an approach can be provided where MOs can be specified and managed in a holistic way. Kantola states that, without ontologies, it is difficult for a manager to perceive, manage and develop MOs in the right way. Nor can management follow the classification and structure of MOs without using ontologies. Kantola calls these ontologies Management Object Ontologies (MOOs). (Kantola 2005, p. 12, 15)

MOOs follow the normal phases of a life cycle: birth, development and death. MOOs can also be divided into parts that start to live their own lives. It is also possible that a number of ontologies join together and form a new “top-level” ontology. The life cycle of MOOs can be influenced by the increased understanding of MOs, which makes it possible to build better ontologies. The ontologies are also influenced by changes in the environments that they have to reflect. (Kantola 2005, p. 16)

All MOs are systems, either open or closed. In most cases they are open systems. According to Kantola, there are two ways of looking and specifying MOOs. (Kantola 2005, p. 17) The constructing of MOOs is presented in Figure 28.

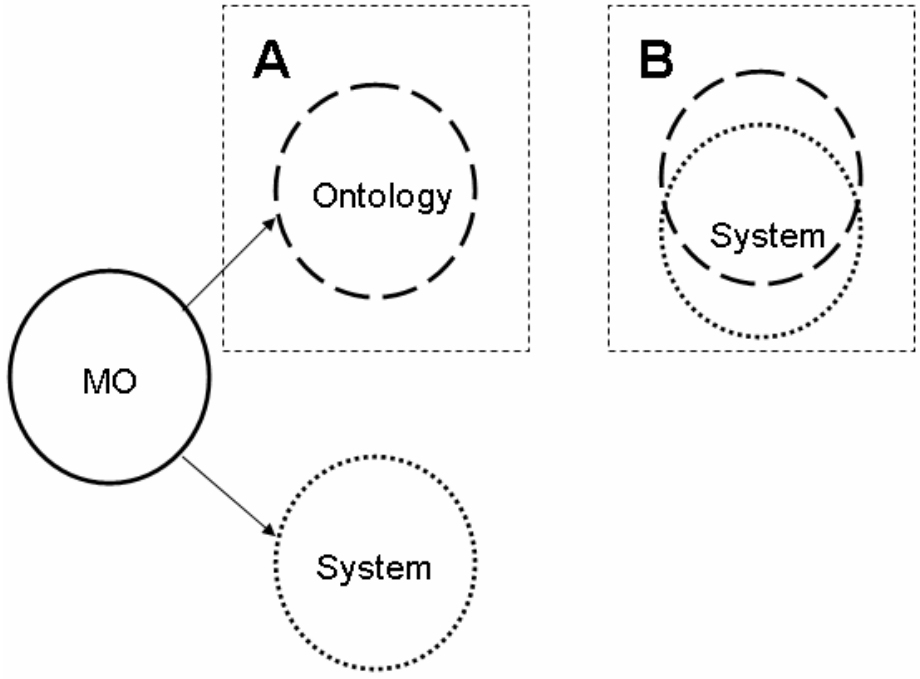

Figure 28. Two ways of constructing MOOs (Kantola 2005, p. 18).

Type A is an ontology that includes one classification of information related to an MO. The content of the ontology is a result of the conceptualization of an MO and the specification of the conceptualization. Type B is both an ontology and a

system that contains two classifications of information related to an MO. Type B also needs a link between these classifications. The content of the ontology results from the conceptualization of an MO and a system and the specification of conceptualizations including the link. (Kantola 2005, pp. 18-19)

2.4.3. Key findings for ontology building

The starting point for this research is the Lituus ontology developed in a master's thesis (Paajanen 2003), which combines both the organizational learning environment and new knowledge creation in the organization. This is a type B ontology that includes both the ontology and the system. With the system level of Lituus, systematic meta-knowledge can be produced related to the organizational learning environment and new knowledge creation. This ontology is built on the generic web-based fuzzy application platform called Evolute. The system supports the use of several assessment systems based on fuzzy logic over the Internet (Kantola 2005). The ontologies for an organizational learning environment (Talbot) and new knowledge creation (Folium) are also type B ontologies. These ontologies include a system level similar to that of Lituus. The following chapter presents the structure and content of these ontologies.

3. CONSTRUCTION OF APPLICATIONS FOR LEARNING AND KNOWLEDGE CREATION

The Co-Evolute methodology, developed at the Tampere University of Technology, Pori unit, is used to meet the requirements of today set by both personnel and operating environment (Vanharanta & Kantola 2004). The Co-Evolute methodology is based on systems science and presents a co-evolutionary management principle. This principle emphasizes the need for fundamental understanding of the natural processes of the continuous co-evolving of individuals and the organizations in which they work. The continuous development of individuals and organizations is a critical requirement for the development of knowledge-based individual and organizational competences, which are needed for business survival and success in knowledge-dominated markets. (Kantola et al. 2006a)

From the viewpoint of co-evolutionary management, it is important to increase the information and the knowledge varieties in the human mind by examining the perceived reality from different points of view. In addition, it is also important to understand both our internal world and the external environment where we live and work. The co-evolutionary view of the internal world extends our ability simultaneously to evaluate and develop our different personal characteristics. In turn, the co-evolutionary view of the external world and processes makes it possible to frame, categorize, conceptualize, understand and perceive the current reality in a diversified way. The co-evolutionary approach helps to identify the need for a change in relation to both people and business processes. (Kantola et al. 2006a)

In this research, the co-evolutionary approach is used to examine the organization’s environment for learning and knowledge creation. In the first phase of this research the Lituus application was developed, which used the core of the Evolute applications in a new way and aimed to map the views of individuals on their operating environment from the viewpoint of learning and knowledge creation. The Evolute applications developed earlier concentrated on the self-assessment of competences among different occupational groups. The goal of the research in the first phase was to create an assessment system that would function like a management decision support system and could help management in making development plans for the organization. However, the Lituus assessment system suffers from the narrowness of the part dealing with knowledge creation in organizations. Lituus includes 97 linguistic statements, of which only 28 discuss new knowledge creation in organizations. In addition, there was a need to examine the organization’s learning environment and new

knowledge creation as their own separate entities. Figure 29 shows how this research followed the Evo model (evolutionary delivery) to build separate ontologies for the learning environment and new knowledge creation.

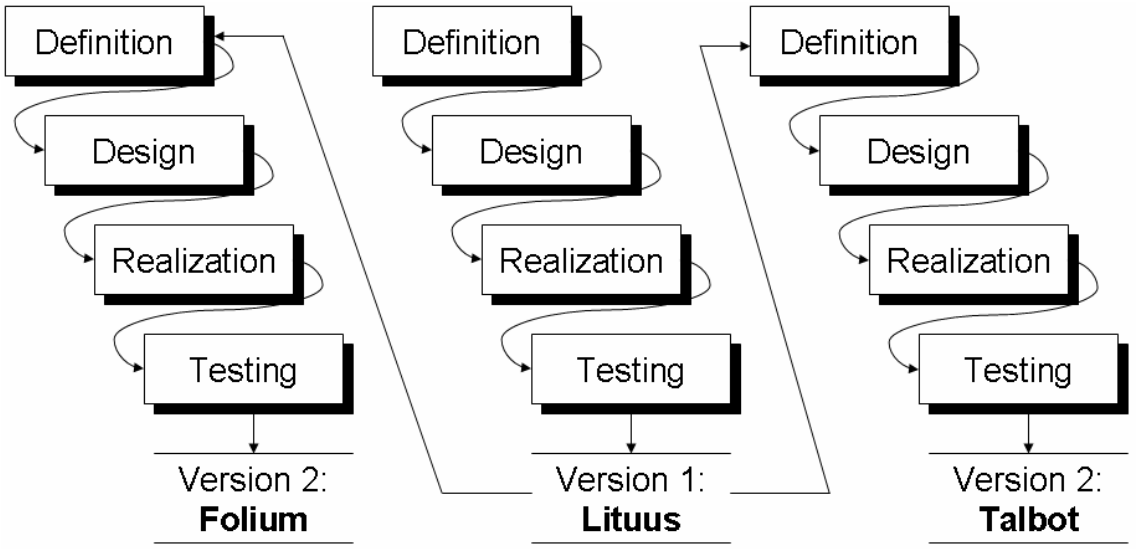

Figure 29. Application of the Evo model (adapted from Haikala & Merijärvi 2002, p. 42).

In the Evo model, the first project builds a core system that is further developed in subsequent projects (Haikala & Merijärvi 2002, p. 41). The Evo model includes a series of repeated cascades, each of which results in a system expanded by new features (Gilb 1998). The further development work in this case resulted in two new assessment systems: Folium, which examined the new knowledge creation in organizations, and Talbot, which examines the organization's learning environment. The following sub-chapters discuss more closely the content of the ontologies and the operating principle behind these three assessment systems.

3.1. The organization's learning environment and knowledge creation - Lituus

With the help of the Lituus assessment system, persons who are working in the organization assess the organization's environment from the viewpoint of learning and knowledge creation. The Lituus assessment system can be used to support the decision-making of the organization’s management. Lituus also enables the follow-up of the implementation of the development activities taken.

In the development work for Lituus, the aim was to define an ontology containing the key features of an organization’s learning environment and knowledge creation. The part of Lituus examining the organization's learning

environment is based on the measurement tool developed by Scott I. Tannenbaum (1997). His measurement tool contains fourteen different sub-areas. One of these was hard to include in the Lituus assessment system for computing-related reasons and was therefore omitted. In Lituus, the different sub-areas of the organization's environment are called organization’s features, which form the sub-classes of the ontology in question. These features are divided into four classes, which makes it possible to examine larger wholes.

The part of Lituus examining new knowledge creation in the organization is based on the measurement tool developed by Jaana Isotalo (2002) in her master’s thesis and on the theory of new knowledge creation developed by Nonaka and Takeuchi (1995). Their theory concentrates on the interaction between tacit and explicit knowledge. Isotalo's tool concentrates on the transmission of tacit knowledge. In Lituus, new knowledge creation is examined with the help of four features and four classes. These four classes are based on Nonaka and Takeuchi’s (1995) four modes of knowledge conversion, which are socialization, externalization, combination and internalization. The features, classes and main classes of Lituus are presented in Table 2.

Table 2. Lituus – features, classes and main classes.

Features	Classes	Main classes	Construct
Opportunity for learning	Learning and toleration of errors	Learning environment	Organizational learning and knowledge creation
Tolerating mistakes as a part of learning			
Striving to avoid errors			
Policies and practices support training	Support to training		
Managers' support to training			
Openness to new ideas and changes	Requirements to new ideas and learning		
Support from co-workers to new ideas			
Demand made by situation			
Awareness of big picture	Individual's awareness and development		
Expectations of and commitments to a high-standard			
Own abilities			
Satisfaction with development			
Training is presented as something positive			
Sharing experiences	Socialization	Organizational knowledge creating activities	
Workers' willingness to spread knowledge	Externalization		
Creating and forming new knowledge	Combination		
Learning by doing and understanding	Internalization		

3.2. The organization's new knowledge creation - Folium

The Folium assessment system contains 53 linguistic statements that are used to assess ten features of an organization. In the Folium assessment system, these features are divided into four classes: socialization, externalization, combination and internalization. This is the same division that was used in the part of the Lituus assessment system examining new knowledge creation. The

features and classes of the Folium assessment system are presented in Table 3.

Table 3. Folium - features and classes.

Features	Classes	Construct
Sharing of experiences	Socialization	Organizational knowledge creation activities
Following other peoples' work		
Spending time and doing things together		
Articulating tacit knowledge	Externalization	
Conceptualizing tacit knowledge		
Merging new knowledge with existing knowledge	Combination	
Spreading new knowledge into the organization		
Evaluation of new knowledge		
Abstract new knowledge in practice	Internalization	
The use of simulation and training		

The linguistic statements in the Folium assessment system are based on the measurement tool developed by Jaana Isotalo (2002), concentrating on the transmission of tacit knowledge, and on the literature review of new knowledge creation in organizations.

3.3. The organization's learning environment - Talbot

The Talbot assessment system contains 69 linguistic statements that are used to assess thirteen features of an organization. These features are divided into four classes: learning and toleration of errors, support to training, requirements to new ideas and learning, and individual's awareness and development. The features and classes of the Talbot assessment system are presented in Table 4.

Table 4. Talbot – features and classes.

Features	Classes	Construct
Opportunity for learning	Learning and toleration of errors	Learning Environment
Tolerating mistakes as a part of learning		
Striving to avoid errors		
Policies and practices support training	Support to training	
Managers' support to training		
Openness to new ideas and changes	Requirements to new ideas and learning	
Support from co-workers to new ideas		
Demand made by the situation		
Awareness of big picture	Individual's awareness and development	
Expectations of and commitments to a high standard		
Own abilities		
Satisfaction with development		
Training is presented as something positive		

The features presented in Table 4 and the linguistic statements of Talbot assessment system are based on Tannenbaum's (1997) measurement tool for examining an organization's learning environment. The tool is used to assess matters related to a positive learning environment in an organization.

3.4. The organization's maintaining systems

The Lituus, Folium and Talbot assessment systems have in common the production of systemic meta-knowledge in relation to the organization’s maintaining systems. The organization’s maintaining systems and their features are presented in Table 5.

Table 5. Organization's maintaining systems and their features.

Maintaining Systems	Maintaining System's Feature
Control Systems (Command - Control, cf. Samuelson 1981)	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 1981)	Autonomy
	Team work
	Rotation of personnel
	Mentoring
	Continuous improvement (Kaizen)
Information Systems (Information - Communication, cf. Samuelson 1981)	Redundancy
	Requisite variety
	Human capital
	Intellectual assets
	Dissemination of local knowledge
	Knowledge channels
	Knowledge activists
Support Systems (Maintenance - Support, cf. Samuelson 1981)	Organizational culture
	Dimensions of care
	Systems of incentives
	Human resources development policy
	Tools supporting learning

The features of the systems presented in Table 5 and their content have been presented in more detail in Chapter 2.3.3.

3.5. Operating principle of the assessment systems

The Lituus, Folium and Talbot assessment systems share the same operating principle. The structure and operating principle of the assessment systems can be presented according to Figure 30.

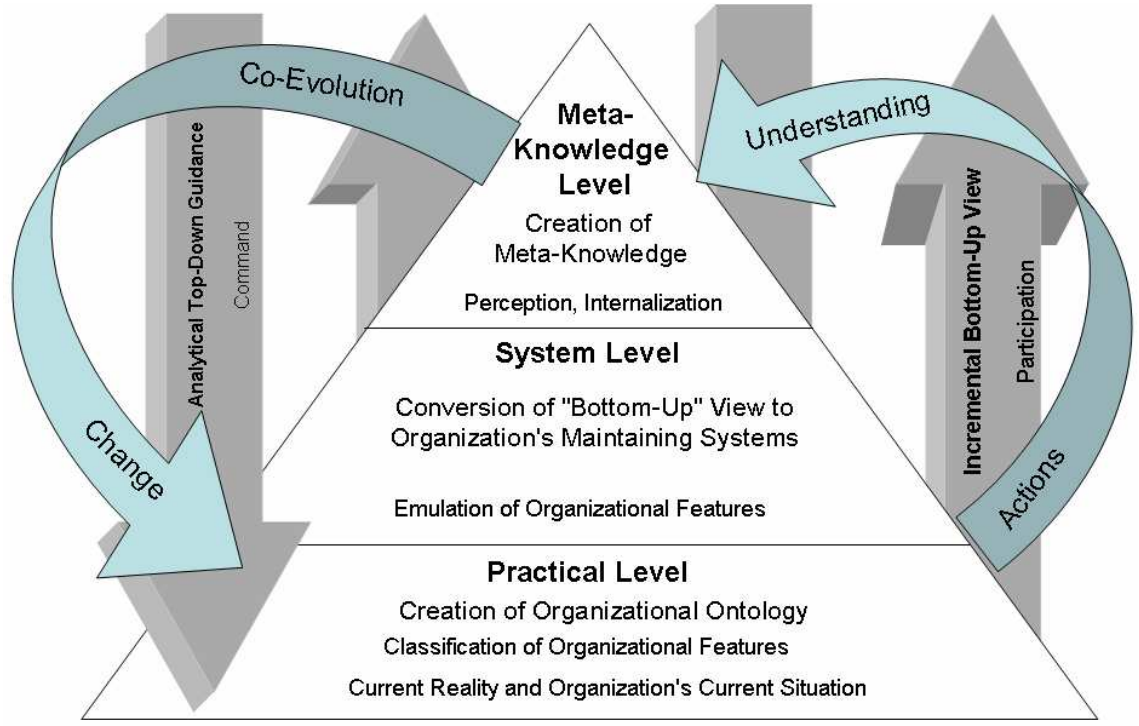

Figure 30. The different levels of the assessment systems (adapted from Aramo-Immonen et al. 2005).

The assessment systems contain three different levels: the practical level, system level and meta-knowledge level. The practical level contains the developed ontology, which includes certain features (sub-classes). These features are further divided into classes and main classes. On the practical level, the best experts to assess the management object in question are the people who work daily in the organization. The views of these persons on the current state and target state for developing the organization's internal operating environment are very important when making development plans for the organization. The people who are working in the organization assess the features with the help of linguistic statements. Figure 31 shows an example of a linguistic statement in the Folium assessment system.

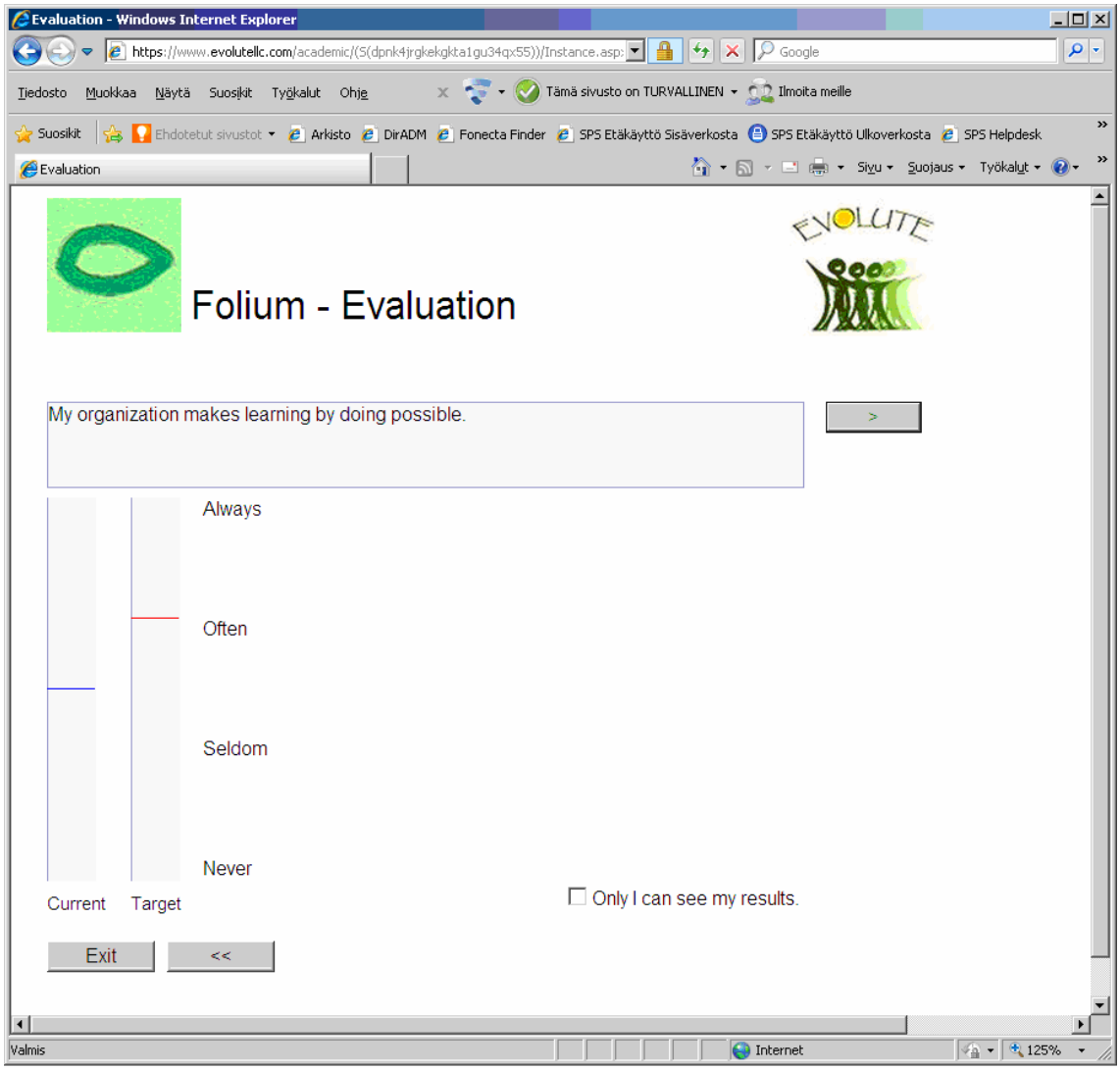

Figure 31. Example statement from the Folium assessment system.

The user of the assessment system uses the mouse to select the level which he or she thinks best describes the situation presented in the linguistic statement. The left-hand assessment bar is used to describe the current state and the right-hand assessment bar the level of the target state for the development of the issue in question (see Figure 31). Figure 32 shows how assessment results are formed on the system level on the basis of the “bottom-up” views of those working in the organization.

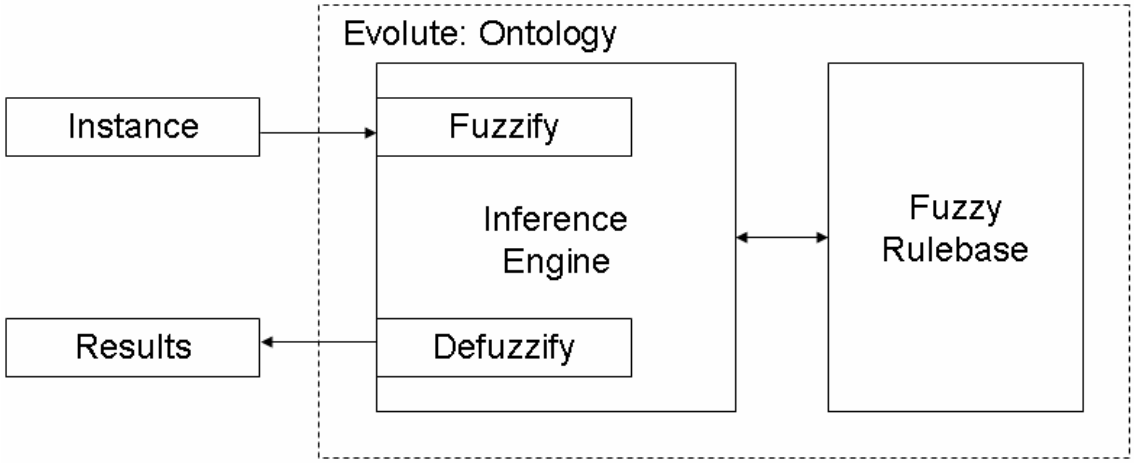

Figure 32. Evolute architecture (Kantola 2005, p. 33).

The fuzzy logic calculation module of the Evolute applications aims to control the informational fuzziness related to human decision-making processes and the natural fuzziness related to individuals' assessments. The fuzzy logic calculation module consists of fuzzying, a fuzzy adjustment base, a fuzzy deducer, and clarification. In fuzzying, inputs are transformed into linguistic terms or fuzzy sets. The fuzzy deducer defines the fuzzy total deduction corresponding to the input (the response) with the help of rules and the data in the fuzzy adjustment base. In the clarification, the response is sharpened into a value in the desired definition set (Kruse et al. 1994, pp. 163-164). The developed assessment systems function according to the following phases (Kantola et al. 2004a):

1. In the first phase, the statements describing the organization's environment are evaluated (instance). The features depicting the organization's features are described in linguistic terms. Inputs are then converted into fuzzy sets (fuzzification).
2. In the second phase, fuzzified inputs are used by an inference engine to evaluate dynamically created fuzzy rules in the rulebase(s). As a result, one fuzzy set for each environment's feature is generated (inferencing).
3. In the third phase, the fuzzy sets are converted into crisp feature values and further to graphical and statistical reports for individuals and groups.
4. In the fourth phase, fuzzy sets are finally converted into crisp meta-classification values and further to graphical and statistical reports for individuals and groups.

Figure 33 shows an example of a graphical report received by an user of the Folium assessment system after assessment.

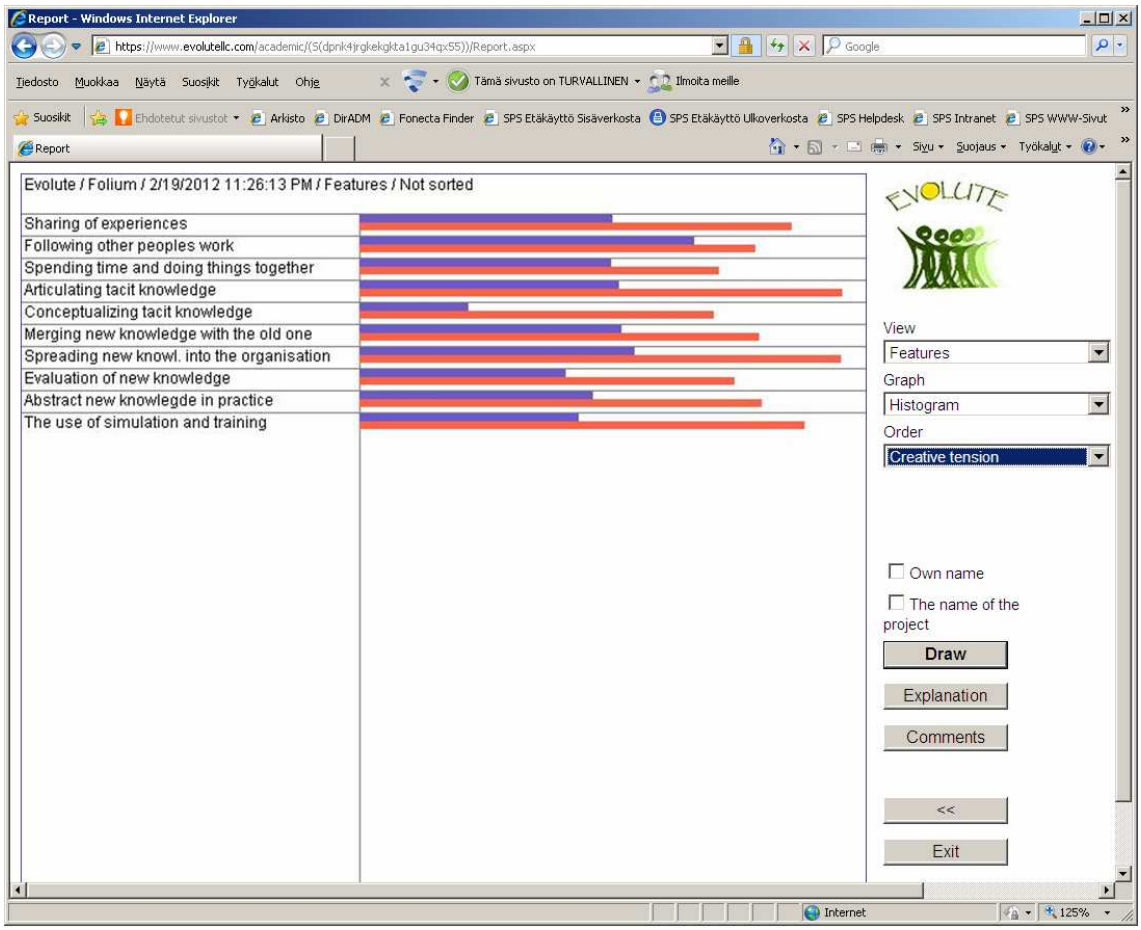

Figure 33. A graphical example report generated in the Folium assessment system.

In the graphical report shown in Figure 33, are presented the ten features contained by the Folium assessment system. The blue bars describe assessments of the current state: the red bars assessments of the target state for the development. The Folium assessment system generates corresponding graphical reports related to classes, main classes, meta-knowledge level maintaining systems and maintaining system's features. Figure 34 shows an example of a numerical report received by an user of the Folium assessment system after assessment.

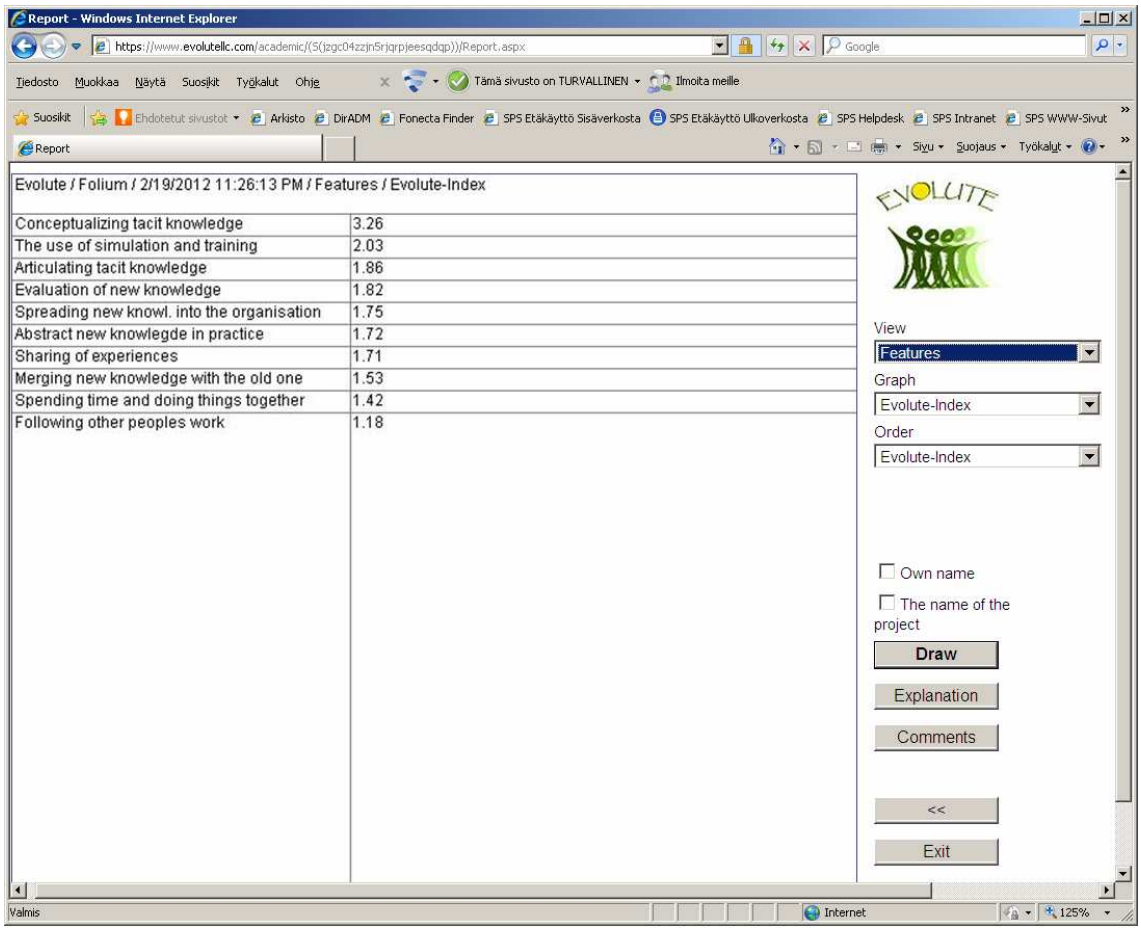

Figure 34. A numerical example report generated in the Folium assessment system.

The Figure 34 shows numerical values related to the Evolute index, which is created by dividing the assessment of the target state for development by the assessment of the current state. The Folium assessment system generates corresponding numerical reports related to classes, main classes, meta-knowledge level maintaining systems and maintaining system's features.

The results of assessments can be used as a basis to open discussions when development plans are being made for the organization. Repeating the assessment at certain intervals, for instance every six months, helps in the supervision of the realization of development plans and in their further clarification. This is long-term development work, and it is important to follow it up regularly. The following sub-chapter presents the ingenious management process, describing the different modules needed when using the assessment systems regularly.

3.6. The ingenious management process

Figure 35 presents a modular view of the ingenious management process described by Kantola (2005).

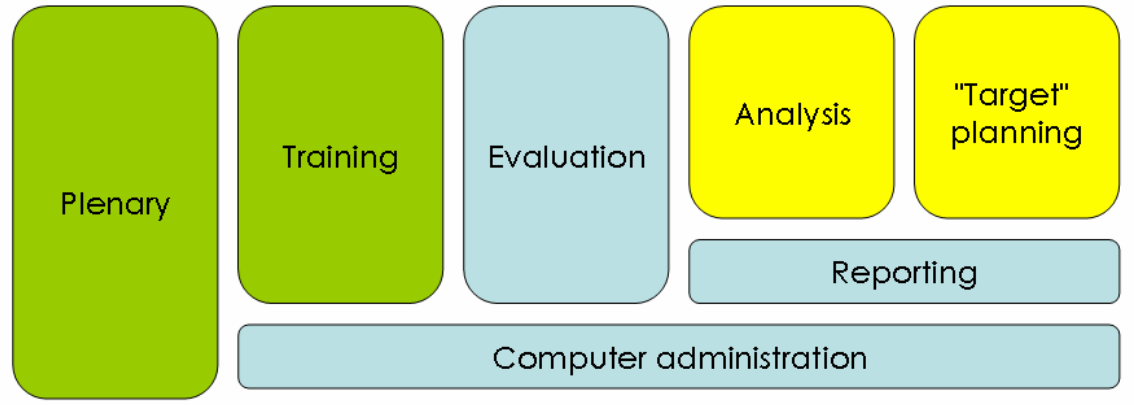

Figure 35. The ingenious management process (Kantola 2005, p. 28).

According to Kantola (2005, p. 28), the modules shown above in green – preparation and technical training – are only needed when the assessment systems are used in the organization for the first time or new people join the organization.

Plenary. At the plenary event, the following issues are presented to those participating in the assessment:

- The theory on which the development work of the assessment systems is based.
- Organizational problems and reasons why there is a need for responsive organizations.
- The content of the assessment systems: features, classes and main classes.
- The operating principle of the assessment systems.
- The interpretation of the graphical reports generated after assessment.

Training relates to the training of the administrator and project manager at the target organization. One person is selected from the company or organization to act as administrator/project manager. The person in question undergoes a brief training course on how persons participating in the assessment can be added to the database of the assessment system. The administrator can follow how many have done the assessment. The administrator is also a contact person at the target organization. The administrator manages all projects, assessments and results of the applications used at the organization.

Evaluation. The evaluation process proceeds through the following steps:

- Opening and adding a new project (administrator).
- Setting a time window for assessments (administrator).
- Adding persons (administrator).
- E-mailing login information to persons participating in the assessment.
- Doing the assessment on the Internet.
- Following the progress of the assessment (administrator).

Reporting. After the assessment, the participants are given a written report on the results.

Analysis. After the deadline set for the assessments, a meeting is arranged for the persons who participated in the assessment. In this meeting, the features and classes of the assessment systems are described in more detail. Also, the concepts related to the meta-knowledge level of the assessment systems are presented. This ensures that the results of the assessment are interpreted correctly and the content of the assessment systems is understood. After this, the group level results of the assessment are presented to the participants.

Target planning. As a result of the analysis meeting, the focus is set on approximately five areas whose development is seen as important based on the assessment results. It is possible to build a development matrix, which collects together the selected development areas. A development matrix defines how the organization should be developed from the viewpoint of learning and knowledge creation. Detailed development plans can be made based on the matrix.

Computer administration. The following issues are included in the computer administration:

- Maintenance of the server.
- Maintenance of data security.
- Maintenance of the database.
- Maintenance of the data.
- Helping of the users.

The modules of the ingenious management process are used to ensure that the assessment systems can be used without problems. The users must know the operating principle of the assessment systems and be able to interpret the results of the assessment correctly. Following the modular structure also

ensures that training and development plans are made on the basis of the assessment results. In the organization's development processes, it is essential that concrete development activities are taken and that their implementation is monitored.

4. DEVELOPMENT OF APPLICATIONS AND CASE STUDIES

This research started in May 2003. In the first phase of the research the goal was to develop a system that could be used in the evaluation of an organization's learning environment and knowledge creation activities. The Lituus application was developed as a result of the first phase of the research. Research was continued, because the view of learning and knowledge creation processes was not yet at a satisfactory level. It was therefore concluded that separate applications were needed for learning environment and knowledge creation activities. In the second phase of the research, the Talbot (learning environment) and Folium (knowledge creation) applications were developed. The development of the applications and results of the case studies which were carried out are presented in the research papers. Figure 36 presents a timeline which describes how the research has proceeded during the years. The empirical results of the research are presented in the research papers attached to this thesis. In this chapter, a summary of each research paper is presented. The results of the latest research are also given.

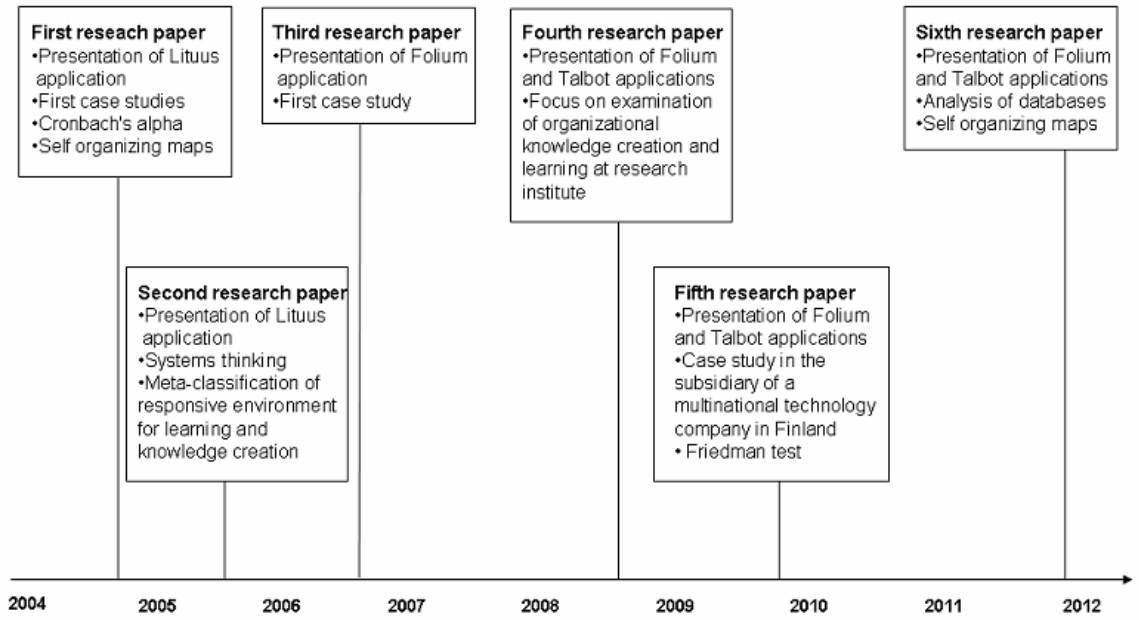

Figure 36. Timeline for development of applications.

4.1. Research papers

First research paper

The first research paper *Evaluating the Organization's Environment for Learning and Knowledge Creatio*n presents the Lituus application and focuses on a

meta-classification of a responsive environment for learning and knowledge creation. This research paper presents the research results from the first phase of the research. The goal of the research paper was to illustrate how the Lituus application can be used to gain a systematic view of an organization's environment for learning and knowledge creation. People working within the organization evaluate its current state and target state with the help of Lituus. As a result of this evaluation, it is possible to visualize the gap between target state and current state, which is proactive vision. This research paper focused on finding out whether proactive vision is individual and unique, or whether it is more like the common perception of the learning environment within the organization.

The research paper also presents the results from the application's first preliminary tests. Lituus was tested in two case studies. The first case study was a laboratory case study which was carried out at the Tampere University of Technology in Pori, Finland. In this test the sample size was eleven persons. The main purpose of this case study was to verify the technical functionality and validity of the Lituus application. The second case study was carried out at the Teollisuuden Voima Oy (TVO) nuclear power plant in Olkiluoto, Finland. The sample size in this test was ten persons. These people had joined the TVO during the period 1998-2003. The results of these two case studies were used to measure the internal consistency of Lituus by calculating Cronbach's alpha values. If Cronbach's alpha value is between the values 0.60 and 0.85 it can be concluded that the indicator has the qualities of a "good indicator" (Tähtinen & Isoaho 2001). In the first laboratory case study, the resulting Cronbach's alpha value was 0.6143. In the second case study the resulting Cronbach's alpha value was 0.7140. According to these two case studies, the internal consistency of the indicator is well within the boundaries of a good measuring indicator. However, because the sample sizes were small, the analysis of the whole sample only gives a directional sense. Nevertheless, this gave a positive signal to carry on the research work.

Self-organizing maps (SOMs) were used to find out whether proactive vision is individual and unique, or whether it is more like the common perception of the learning environment within the organization. SOMs were applied to study the group results. SOMs help in clustering individuals' views on a specific evaluation object. The SOM, which is presented in the research paper, suggests that the evaluations from all ten participants from the TVO case study belong to the same one cluster. This suggests that in the TVO case study proactive vision was perceived in a similar way. These preliminary tests showed that Lituus can point out those areas where the organization should direct its focus on development based on meta-classification. It was concluded that more

case studies were needed to ensure that the results given by Lituus are universally applicable.

Second research paper

The second research paper *Applying Systems Thinking in the Evaluation of Organizational Learning and Knowledge Creation* emphasizes systems thinking. The goal of the research paper was to show that Lituus 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. It showed that Lituus can be used to gather knowledge from the people working in the organization. Lituus interprets this knowledge and produces results according to given input data. The results suggest the areas where development efforts would be the most productive. This knowledge helps in developing the organization's mental models, actions and know-how. In double-loop learning, information and feedback about the real world not only alter decisions within the context of existing frames and decision rules but also within our mental models (Sterman 2000). It is therefore possible that the use of Lituus could also lead to double-loop learning. Lituus gives information feedback about the real world which may contradict the dominant mental models of the organization. Consequently, development efforts are directed towards producing a more responsive environment for future learning and knowledge creation.

The research paper also presents examples of graphical reports from the Lituus application. The results of the first two case studies were also used in this research paper to prove that Lituus can aid the formation of a systemic view of an organization's learning and knowledge creation environment. Lituus forms a meta-classification for the responsive environment for learning and knowledge creation. It was concluded that Lituus can point out the areas where the organization should direct its focus on development, based on this meta-classification.

Third research paper

The third research paper *FOLIUM – Ontology for Organizational Knowledge Creation* presents the structure of the Folium application. The development of Folium was based on the ontology for organizational knowledge creation. With the help of Folium, a bottom-up view is formed to capture the real understanding of an organization's knowledge creation activities. Folium can be used to help the organization's management in the decision-making process, when target development plans are being made to improve and support organizational knowledge creation. The goal of the research paper was to

illustrate how the Folium application can be used to support the development of an organization's knowledge creation process. The research paper presents the results from the first case study. Seventeen students taking the course *Learning and Learning Environments* during the spring term of 2006 at Tampere University of Technology in Pori participated in this case study. The main purpose of this case study was to verify the technical functionality and validity of the Folium application. Graphical reports of the summary results are presented in the research paper. Although the sample size of the case study was quite small, discussions with the students validated the results to some extent. The first test results of the Folium application also verified the technical functionality of the application. It was concluded that, based on the first test results, Folium is capable of visualizing an organization's proactive vision concerning knowledge creation activities.

Fourth research paper

The fourth research paper *Knowledge Creation and Learning in Organizations – Measuring Proactive Vision Using the Co-Evolute Methodology* presents both the Folium and Talbot. The goal of the research paper was to examine organizational knowledge creation and learning with the help of Folium and Talbot at a research institute in Turku, Finland. The case study was carried out at the Institute for Advanced Management Systems Research (IAMSR) at Åbo Akademi University (Turku) during the spring of 2005. A demonstration and information seminar was held for participants of the case study before they used the Folium and Talbot applications. Twelve persons participated in the Folium case study and nine persons participated in the Talbot case study. The case study focused on studying proactive vision, which is the gap between current and target states. The results of the case study were examined at two levels, the feature level and the group level. Radar diagrams were used to present the feature level results. The case study proved that the Folium and Talbot applications could be used to identify the areas which could and should be developed through targeted training.

It was concluded that some issues required further research. Firstly, the setting of a research institute is not directly comparable to that of industry. For example, there is a less coherent common goal inside a research institute than in a company. Presumably, a researcher's motivation (doctoral degree, publications, etc.) is somewhat more individualistic than it would be in industry. In order to assess this, a comparative study should be carried out. Secondly, are there peculiarities concerning team-based work in a research environment, compared to industry? Thirdly, some of the research results concerning knowledge transfer at IAMSR should be further investigated. Finally, a

longitudinal study would be interesting to carry out, primarily to assess how the institute has developed since 2005.

Fifth research paper

The fifth research paper *Development of Personal and Organizational Competences in a Technology Company* aims to illustrate how the Co-Evolute methodology can be applied to capture the proactive vision of the personnel of a technology company in terms of personal and organizational development, from the viewpoint of learning and knowledge creation. Four different applications were used to gain a systematic view of the development needs of the technology company: Cardioid to evaluate a person's physical competences; Cycloid to evaluate the project manager's generic and specific competences; Folium to evaluate the organizational environment from the viewpoint of new knowledge creation and Talbot to evaluate the organizational environment from the viewpoint of learning. The case study was carried out in the subsidiary of a multinational technology company in Finland. The evaluation was performed by 24 employees who are responsible for assigned tasks without direct supervision, such as contract managers and design project leaders. These persons answered all the linguistic statements of all four applications. The Evolute program transformed the answers into a numerical value between 0 and 1. From these numerical values one single value for each corresponding feature and for each respondent is deducted with the use of fuzzy logic. Every respondent has one value for each single feature.

Group results were analysed using the Friedman test (Conover 1999). The Friedman test ranks all the values of the features of one participant. The feature values are replaced with the corresponding ranking, with the smallest value replaced by ranking 1 and the highest value given the ranking of the total amount of features. The Friedman test also calculates the minimum difference value. The minimum difference is a statistical calculation based on the perceived rankings. It states what must be the minimum difference between two summed rankings to be considered statistically unequal. With the help of the Friedman test it is possible to divide the results into different groups based on the current state and target state values. It was concluded that identifying the areas where the largest proactive vision for the future exists is possible with the use of the Co-Evolute methodology. It was also concluded that it would be of great value to repeat the study at a future date, for example after a year, in order to see how the views of the employees have changed.

Sixth research paper

The sixth research paper *Showing Asymmetries in Knowledge Creation and Learning through Proactive Vision* focuses on knowledge creation and learning concepts with the help of the Folium and Talbot applications. The research paper shows the asymmetries between how people in business and the academic world view their current situation, as well as how they would like to see the future. The research paper presents the possibilities to use the established database to group the whole dataset to show the asymmetry between the proactive vision and the current and future desires to improve knowledge creation and learning in the organization. The paper also presents the evidence supporting the use of this methodology to reveal asymmetries and why it is so important to understand these in terms of management and leadership.

Using the Evolute system, 264 Talbot instances (216 academic and 48 company instances) and 300 Folium instances (247 academic and 53 company instances) were collected. The academic dataset was collected during the period of June 2005 - June 2010 in universities in Finland, Spain, Poland and South Korea. The company dataset was collected during the period of December 2005 - August 2007 in Finland in organizations that represent different areas of work and business. Large parts of these two datasets do not have detailed demographic labels associated with the instances and therefore that information cannot be presented. Adding one's demographic data to instances during self-evaluation was always voluntary. The results of the study were presented with the help of bar diagrams. Also, self-organizing maps (SOMs) were used to examine the patterns found in the dataset. SOMs are presented from both the Folium and Talbot datasets. It was concluded that the initial results gave a solid indication of which areas could be improved in universities and companies in order to really enable knowledge creation and organizational learning in these organizations.

Table 6 gives a summary of how the applications were reviewed in each case study. It also summarizes how the research results are presented in each research paper.

Table 6. Research papers and review of applications.

Research paper	Review of applications					
	Application	**Verification**	**Validation**	**Reliability**	**Presentation of results**	**Usability**
Evaluating the Organization's Environment for Learning and Knowledge Creation	Lituus	Technical functionality tested in the first two case studies	Results of the first two case studies	Cronbach's alfa values	Graphical reports and self-organizing maps	Tested in the first two case studies
Applying Systems Thinking in the Evaluation of Organizational Learning and - Knowledge Creation	Lituus	Technical functionality tested in the first two case studies	Results of the first two case studies		Graphical reports	Tested in the first two case studies
FOLIUM - Ontology for Organizational Knowledge Creation	Folium	Technical functionality tested in the case study	Results of the case study and discussions with students		Graphical reports	Tested in the case study
Knowledge Creation and Learning in Organizations - Measuring Proactive Vision Using the Co-Evolute Methodology	Folium and Talbot	Technical functionality of tested in the case study	Results of the case study		Radar diagrams and bar diagrams	Tested in the case study
Development of Personal and Organizational Competences in a Technology Company	Folium and Talbot	Technical functionality of tested in the case study	Results of the case study		Friedman test	Tested in the case study
Showing Asymmetries in Knowledge Creation and Learning through Proactive Vision	Folium and Talbot	Technical functionality of tested in the case studies	Analysis of Folium and Talbot datasets		Bar diagrams and self-organizing maps	Tested in the case studies

4.2. Latest research

Talbot and Folium ontologies are being used as a basis for other ontologies as well. Serpentine is an ontology that defines features of the safety culture (Porkka et al. 2010). There are two main categories in Serpentine: the learning

environment and knowledge creation activities. The content of the ontology for the safety culture is presented in Table 7.

Table 7. Content of the ontology for the safety culture (cf. Porkka et al. 2010).

Features	Classes	Main classes
Safety training	Learning and toleration of errors	Learning environment
Support and encouragement		
Safety policy	Support of safety training and education	
Management		
Organization's openness to new ideas and change	Preconditions for the development of safety culture	
Atmosphere		
Efficiency of safety actions		
Resourcing for safety		
Working environment		
Risk management		
Safety consciousness and responsibility	Individual's awareness and development	
Attitudes towards safety		
Co-operation	Socialization	Organizational knowledge creating activities
Flow of information	Externalization	
Safety rules and regulations		
Creation of new knowledge	Combination	
Learning by doing	Internalization	

The division into the classes and main classes of the Serpentine application follows the structure of the Talbot and Folium applications. The features of the Serpentine application are different due to the different content of the management object examined. Learning and knowledge creation are also important from a safety culture point of view. Without them it is not possible to change the culture of an organization. The Serpentine application is also built on the same generic web-based fuzzy application platform as Talbot and Folium. In this research, the results from a safety culture assessment carried out in companies belonging to the industrial sector and the energy sector are presented. Only the results of the classes are presented and analysed here.

4.2.1. Results from the industrial sector

Ten companies in the industrial sector used the Serpentine application in a safety culture assessment survey. Some of these companies produce products such as metals and chemicals and some produce services, such as maintenance services. The sample size in the industrial sector was 408 persons. Traditionally in human sciences, group results are presented in sums and means. If interpreted strictly in the statistical sense, this is not acceptable. Instead of direct values, rankings should be used to present group results. Each respondent's personally given values of features can be replaced with the corresponding ranking. The smallest value is replaced by the ranking 1 and the highest value given the ranking of the total amount of features. Thereafter, it is possible to sum the rankings and calculate means. Therefore, in this research group results are calculated with the Friedman test (Conover 1999), which is based on rankings. Figure 37 presents the current state rankings of all ten companies.

CURRENT STATE	All companies	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Company H	Company I	Company J
	md=0,28	md=0,75	md=0,48	md=1,86	md=1,91	md=1,17	md=1,08	md=1,18	md=1,40	n=2,04	n=0,92
Feature	n=408	n=54	n=128	n=9	n=9	n=26	n=27	n=87	n=18	n=8	n=42
Individual's awareness and development	6,70	7,0	6,6	6,3	6,9	6,4	6,3	6,7	6,8	7,3	6,8
Opportunity for learning	6,06	6,3	6,2	6,8	5,0	5,8	6,8	6,4	5,7	4,6	4,8
Learning and toleration of errors	4,87	3,5	5,6	5,2	4,9	3,7	5,3	5,2	3,8	4,3	4,9
Externalization	4,42	4,6	4,3	4,1	4,8	4,0	3,9	4,7	4,4	6,3	4,3
Socialization	3,92	4,5	3,6	5,0	4,9	3,8	3,8	3,3	4,8	3,6	4,8
Internalization	3,76	3,5	3,6	2,4	4,2	5,5	3,2	3,6	3,7	3,8	4,3
Combination	3,27	3,5	3,2	2,9	2,5	4,0	3,6	3,2	3,3	2,9	2,8
Preconditions for the development of safety culture	3,01	3,1	2,9	3,3	2,8	2,8	3,2	2,9	3,7	3,3	3,2

Figure 37. Current state rankings of the industrial sector.

As shown in Figure 37, the grey areas represent features having high rankings and the blue areas represent features having low rankings. *Individual's awareness and development* is a feature with a high current state ranking in all of the industrial sector companies. Also, the feature *Opportunity for learning* had high current state rankings in six companies. The feature *Preconditions for the development of safety culture* has a low current state ranking in all companies. The feature *Combination* also received low rankings in almost all of the companies. The exception was company E, where the feature *Combination* received neutral rankings.

There are more features with low rankings (blue areas) than high rankings (grey areas). This means that the respondents did not have a unanimous view of the rankings. The better the consensus among the respondents, the fewer features

there are in the groups of high and low level rankings. As shown by Figure 37, in companies C, F, H and I there are many features in the groups of high and low level rankings.

Based on the current state rankings, it can be concluded that issues related to personal development were perceived at a higher level than issues related to the organization's atmosphere and environment. Figure 38 presents the target state rankings of all ten companies in the industrial sector.

TARGET STATE	All companies	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Company H	Company I	Company J
	md=0,28	md=0,81	md=0,50	md=1,99	md=1,51	md=1,14	md=1,07	md=0,61	md=1,39	md=1,90	md=0,84
Feature	n=408	n=54	n=128	n=9	n=9	n=26	n=27	n=87	n=18	n=8	n=42
Individual's awareness and development	6,04	6,3	5,7	5,1	5,3	5,8	6,1	6,6	6,1	7,1	6,0
Opportunity for learning	5,61	5,8	5,9	5,7	5,7	6,0	6,1	5,4	4,8	4,5	5,0
Learning and toleration of errors	5,27	4,9	5,7	5,0	5,1	5,2	5,9	4,8	4,7	4,9	5,5
Externalization	4,93	4,3	4,9	4,2	5,3	4,9	5,1	5,5	4,9	5,3	4,8
Internalization	4,25	4,0	4,4	3,4	4,7	4,8	3,2	4,2	4,2	4,7	4,5
Socialization	4,01	4,4	3,9	5,3	4,1	4,1	3,5	3,5	4,7	3,6	4,7
Preconditions for the development of safety culture	3,51	3,7	3,4	3,2	2,7	2,9	3,5	3,7	3,5	4,2	3,5
Combination	2,38	2,6	2,1	4,1	3,1	2,3	2,6	2,4	3,2	1,9	2,1

Figure 38. Target state rankings of the industrial sector.

The feature *Individual's awareness and development* also has high target state rankings in all the companies. The violet areas mean that the feature in question belongs to both high and low level rankings. This can be seen in the case of Company C. The feature *Combination* has low target state rankings in all the companies. Figure 38 shows that in companies C, D, E, F and H there are many features in the groups of high and low level rankings. In these companies the respondents did not have a unanimous view of the features' rankings.

Based on the target state rankings, it can be concluded that issues related to personal development were perceived at a high level. Issues related to the combination of knowledge had low target state rankings. The result is quite similar to the current state rankings. Figure 39 presents the proactive vision rankings of all ten industrial sector companies. The proactive vision is the gap between the target state and the current state.

PROACTIVE VISION	All companies	Company A	Company B	Company C	Company D	Company E	Company F	Company G	Company H	Company I	Company J
	md=0,31	md=0,85	md=0,53	md=2,12	md=2,10	md=1,21	md=1,21	md=0,67	md=1,55	n=2,29	n=0,99
Feature	n=407	n=54	n=128	n=9	n=9	n=26	n=27	n=87	n=18	n=8	n=42
Preconditions for the development of safety culture	5,79	5,7	6,2	5,0	5,9	5,7	5,3	5,8	4,6	6,0	5,6
Externalization	5,01	4,6	5,1	4,4	4,7	5,7	5,7	5,2	4,9	3,8	4,5
Internalization	5,00	5,1	5,5	5,9	5,3	3,5	4,5	5,1	4,5	5,6	4,5
Socialization	4,77	4,5	5,1	4,7	3,6	4,7	4,2	5,1	4,6	4,4	4,4
Learning and toleration of errors	4,74	5,8	4,1	4,3	5,1	5,9	5,4	4,1	5,4	4,7	5,2
Opportunity for learning	3,78	3,6	3,6	2,9	4,3	4,0	4,1	3,2	3,7	5,3	5,1
Combination	3,59	3,4	3,6	6,0	4,8	3,1	2,5	4,0	4,4	2,3	3,2
Individual's awareness and development	3,32	3,5	2,9	2,7	2,4	3,5	4,3	3,4	3,9	4,0	3,5

Figure 39. Proactive vision rankings of the industrial sector.

The feature *Preconditions for the development of safety culture* has high proactive vision rankings in all the companies. Proactive vision rankings were not perceived unanimously, because in many companies there are many features in the groups of high and low level rankings. The feature *Individual's awareness and development* has low proactive vision rankings in all the companies except in company F, where it had a neutral ranking. The feature *Combination* also has low proactive vision rankings in companies A, E, F, H, I and J. In companies A, C, D, E, G and H the feature *Opportunity for learning* had low-level rankings.

Based on the proactive vision rankings of the industrial sector, it can be concluded that organization level issues are perceived to have the highest proactive vision. Issues related to personal development are perceived to have the lowest proactive vision. This means that respondents perceive these issues as already being at a good level or they are not aware of how these issues should be developed.

4.2.2. Results from the energy sector

Companies belonging to the energy sector are involved in selling and distributing energy. The sample size in the energy sector was 152 persons. Figure 40 presents the current state rankings of all three companies.

CURRENT STATE Feature	All companies md=0,47 n=152	Company A md=0,72 n=67	Company B md=1,39 n=19	Company C md=0,71 n=66
Opportunity for learning	6,28	6,64	4,79	6,32
Individual's awareness and development	6,24	5,99	6,42	6,41
Socialization	4,89	4,62	5,47	5,02
Externalization	4,55	4,66	5,50	4,18
Internalization	3,84	3,75	3,53	4,07
Learning and toleration of errors	3,49	3,54	4,11	3,27
Preconditions for the development of safety culture	3,48	3,58	3,05	3,47
Combination	3,23	3,21	3,13	3,26

Figure 40. Current state rankings of the energy sector.

As shown in Figure 40, the features *Opportunity for learning* and *Individual's awareness and development* have high current state rankings in companies A and C. In company B the features *Individual's awareness and development, Socialization* and *Externalization* have the highest current state rankings. The features *Combination*, *Preconditions for the development of safety culture* and *Learning and toleration of errors* have low-level rankings in all the companies. In company B there are many features in the groups of high and low rankings. This means that the respondents did not have a unanimous view of the features' rankings.

Based on the current state rankings, it can be concluded that issues related to personal development were perceived at a high level in all the companies. Issues related to the organization's environment had low-level rankings. In Figure 41 is presents the target state rankings of all three companies in the energy sector.

TARGET STATE Feature	All companies md=0,49 n=152	Company A md=0,74 n=67	Company B md=1,46 n=19	Company C md=0,72 n=66
Opportunity for learning	5,96	6,34	5,08	5,80
Individual's awareness and development	5,90	5,48	6,26	6,23
Socialization	4,75	4,57	4,84	4,92
Externalization	4,67	4,75	4,05	4,80
Learning and toleration of errors	4,37	4,57	4,45	4,09
Internalization	3,89	4,06	2,63	4,06
Preconditions for the development of safety culture	3,72	3,48	4,16	3,85
Combination	2,73	2,75	4,53	2,24

Figure 41. Target state rankings of the energy sector.

The feature *Opportunity for learning* has high target state rankings in all three companies. In companies B and C the feature *Individual's awareness and development* also had high target state rankings. The feature *Combination* has low target state rankings in companies A and C. In company B the features *Internalization* and *Externalization* have the lowest target state rankings.

Based on these target level rankings, it can be concluded that issues related to modes of knowledge conversion have quite low rankings. Individual development had high rankings in all the companies. Figure 42 presents the proactive vision rankings of all three companies in the energy sector.

PROACTIVE VISION Feature	All companies md=0,52 n=152	Company A md=0,78 n=67	Company B md=1,42 n=19	Company C md=0,79 n=66
Preconditions for the development of safety culture	5,52	5,36	6,11	5,55
Learning and toleration of errors	5,43	5,54	5,24	5,36
Internalization	4,94	5,23	4,11	4,79
Externalization	4,59	4,56	2,50	5,21
Socialization	4,46	4,72	3,89	4,32
Combination	3,88	3,78	5,63	3,55
Opportunity for learning	3,60	3,22	4,71	3,67
Individual's awareness and development	3,59	3,59	3,82	3,56

Figure 42. Proactive vision rankings of the energy sector.

The features *Preconditions for the development of safety culture* and *Learning and toleration of errors* have high proactive vision rankings in all three companies in the energy sector. Also, in companies A and C the feature *Internalization* had high proactive vision rankings. The features *Individual's awareness and development, Opportunity for learning and Combination* have low proactive vision rankings in companies A and C. In company B, in addition to the feature *Individual's awareness and development*, also the features *Socialization* and *Externalization* have low proactive vision rankings.

Based on the proactive vision rankings, it can be concluded that in the energy sector issues related to modes of knowledge conversion have quite neutral proactive vision rankings. Issues related to the organization's environment are perceived to have high proactive vision.

4.2.3. Comparison of results between industrial and energy sectors

In this sub-chapter the results between the industrial and energy sectors are compared. The overall sample size is 560 persons. Figure 43 presents the comparison of current state rankings between the industrial and energy sectors.

ENERGY SECTOR		INDUSTRIAL SECTOR	
CURRENT STATE	All companies md=0,47 n=152	CURRENT STATE	All companies md=0,28 n=408
Feature		Feature	
Opportunity for learning	6,28	Individual's awareness and development	6,70
Individual's awareness and development	6,24	Opportunity for learning	6,06
Socialization	4,89	Learning and toleration of errors	4,87
Externalization	4,55	Externalization	4,42
Internalization	3,84	Socialization	3,92
Learning and toleration of errors	3,49	Internalization	3,76
Preconditions for the development of safety culture	3,48	Combination	3,27
Combination	3,23	Preconditions for the development of safety culture	3,01

Figure 43. Comparison of current state rankings in the energy and industrial sectors.

As shown in Figure 43, the feature *Individual's awareness and development* had high current state rankings in both sectors. In the energy sector the feature *Opportunity for learning* also has high current state rankings. The features *Preconditions for the development of safety culture* and *Combination* had low current state rankings in both sectors. There is a difference in the current state rankings of these two sectors regarding the feature *Learning and toleration of errors*. In the energy sector this feature is in the group of low-level rankings. In the industrial sector this feature is in the group of neutral level rankings, but closer to the group of high-level rankings than the group of low-level rankings.

Based on the current state rankings, it can be concluded that the features are perceived quite similarly. Issues related to personal development were perceived at a high level in both sectors. Figure 44 presents a comparison of target state rankings between the industrial and energy sectors.

ENERGY SECTOR		INDUSTRIAL SECTOR	
TARGET STATE	All companies	TARGET STATE	All companies
	md=0,49		md=0,28
Feature	n=152	Feature	n=408
Opportunity for learning	5,96	Individual's awareness and development	6,04
Individual's awareness and development	5,90	Opportunity for learning	5,61
Socialization	4,75	Learning and toleration of errors	5,27
Externalization	4,67	Externalization	4,93
Learning and toleration of errors	4,37	Internalization	4,25
Internalization	3,89	Socialization	4,01
Preconditions for the development of safety culture	3,72	Preconditions for the development of safety culture	3,51
Combination	2,73	Combination	2,38

Figure 44. Comparison of target state rankings in the energy and industrial sectors.

As shown by Figure 44, the feature *Individual's awareness and development* had high current state rankings in both sectors. The features belonging to the group of high rankings of the target state are the same as in the current state rankings. The feature *Combination* had the lowest target state rankings in both sectors. Based on the comparison of target state rankings between the industrial and energy sectors it can also be concluded that rankings belonging to different groups are quite similar in both sectors. Figure 45 presents a comparison of proactive vision rankings between the industrial and energy sectors.

ENERGY SECTOR		INDUSTRIAL SECTOR	
PROACTIVE VISION	All companies	PROACTIVE VISION	All companies
	md=0,52		md=0,31
Feature	n=152	Feature	n=407
Preconditions for the development of safety culture	5,52	Preconditions for the development of safety culture	5,79
Learning and toleration of errors	5,43	Externalization	5,01
Internalization	4,94	Internalization	5,00
Externalization	4,59	Socialization	4,77
Socialization	4,46	Learning and toleration of errors	4,74
Combination	3,88	Opportunity for learning	3,78
Opportunity for learning	3,60	Combination	3,59
Individual's awareness and development	3,59	Individual's awareness and development	3,32

Figure 45. Comparison of proactive vision rankings in the energy and industrial sectors.

Figure 45 shows that the feature *Preconditions for the development of safety culture* has the highest proactive vision rankings in both sectors. The features *Individual's awareness and development* and *Combination* belong to the group of low proactive vision rankings in both sectors. There is a difference in the proactive vision rankings of these two sectors regarding the feature *Learning and toleration of errors*. In the energy sector this feature is in the group of high-level rankings. In the industrial sector this feature is in the group of neutral level rankings, but closer to the group of low-level rankings than the group of high-level rankings.

5. DISCUSSION AND CONCLUSIONS

The objective of this research was to develop an assessment system to support collective change management and leadership from the viewpoint of learning and knowledge creation. With the help of this system, it is possible to understand better the concepts related to learning and knowledge creation, open a dialogue between members of the organization, gain a collective view of the organization's current state and target state regarding learning and knowledge creation, plan development activities and follow up the progress. This chapter discusses the theoretical and practical contribution of this research in more detail. The research results and methods are assessed and suggestions for future research are made.

5.1. Contribution of the research

This research started from the need to help organizations to understand and manage the concepts related to learning and knowledge creation better. This is challenging because the concepts related to learning and knowledge creation are often very abstract in nature. For this purpose three ontologies were presented in this research: Lituus - organizational learning and knowledge creation, Talbot - the organization's learning environment and Folium - the organization's new knowledge creation. Figure 46 summarizes the main results of this research.

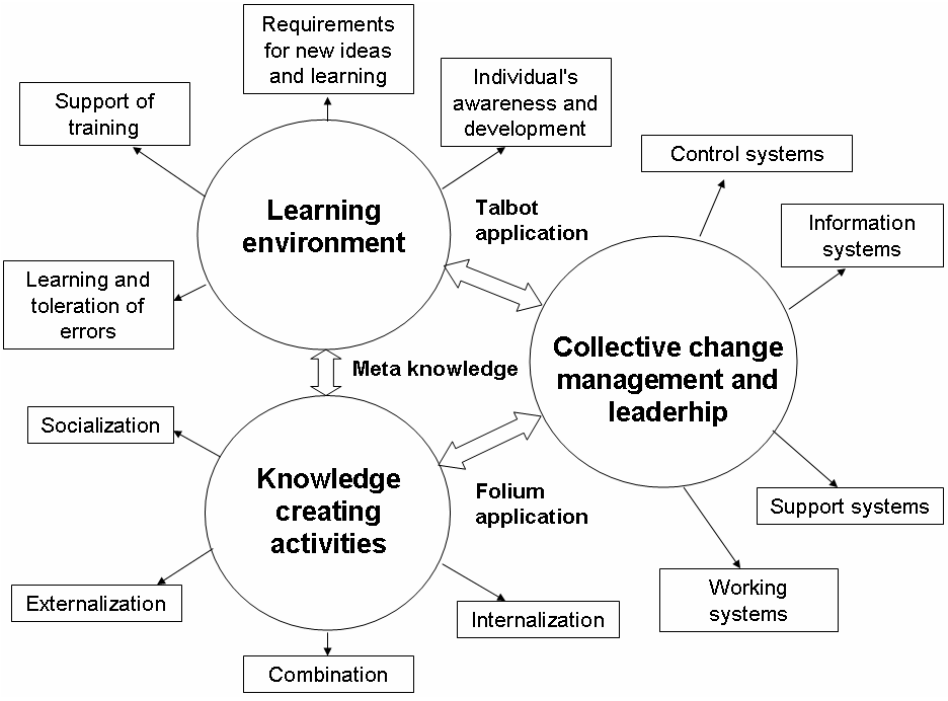

Figure 46. Theoretical and practical results of the research.

The left-hand side of Figure 46 illustrates the theoretical results of this research. Ontologies for learning environment and knowledge creating activities contain the key features that are used to gain an overall picture of issues related to learning and knowledge creation. In the first phase of the study, a common ontology was created for learning and knowledge creation. This ontology contains seventeen features, which are divided into eight classes. A part of the ontology that examines the learning environment is based on the measurement tool developed by Scott I. Tannenbaum (1997). The other part of the ontology, which examines new knowledge creation, is based on the theory developed by Nonaka and Takeuchi (1995). Jaana Isotalo's (2002) research results were also used in the development work. In addition, a responsive environment for learning and knowledge creation was developed. This new construct describes the main methods and issues to support an organization's development from a management and leadership point of view. The main components are four maintaining systems: control systems, working systems, information systems and support systems. These systems include 27 maintaining systems' features. These features have connections to linguistic statements about the organization's learning environment and knowledge creation. These connections were made on the basis of the literature review. Therefore, as a result of this research a completely new framework is presented to the field of study.

In the second phase of the research, separate ontologies were developed for the learning environment and knowledge creation. The ontology for the learning environment contains thirteen features and four classes. The ontology for knowledge creation contains ten features and four classes. These ten features, which have been defined based on the literature review, help in gaining a better understanding of concepts related to the four modes of knowledge conversion, which are socialization, externalization, combination and internalization. The ontology for knowledge creation provides a new framework to describe the different modes of knowledge creation.

The developed ontologies have also been used in different areas of research. Some parts of the ontologies for learning environment and knowledge creation are included in the ontology for safety culture. Both ontologies have also been used in the study of sustainable development strategies (Vanharanta et al. 2010). The overall construction in this area of research combines three different ontologies: sustainable development ontology, knowledge creation ontology and learning ontology. These studies show that the ontologies developed are not only limited to the research done in the area of learning and knowledge

creation. Learning and knowledge creation are key issues in every process of change.

5.2. Assessment of the research results

The developed ontologies were built on a generic web-based fuzzy application platform, which supports the use of applications on the Internet (Kantola 2005). These applications enable one to obtain a collective view of an organization's current state and target state regarding knowledge creation and learning. These applications have been tested in several case studies. Chapter 4 presented a summary of the research results from six research papers and the results of a safety culture survey in the industrial and energy sectors. As a result of the case studies presented in these research papers, the verification, validation and reliability of the research results could be studied. These case studies have proven the technical functionality of the applications. The reliability of the results has been examined in two different case studies with the help of Cronbach's alpha values.

Different methods were also used in the case studies to present the research results. Self-organizing maps and the Friedman test were used to visualize the research results. It was also proven that by using these applications it is possible to gain a collective view of an organization's environment for learning and knowledge creation. The applications also include the meta-level, which can produce meta-knowledge related to management and leadership of organizational learning and knowledge creation. Meta-knowledge forms a view of which methods and issues help the organization in the development work towards a responsive environment for learning and knowledge creation.

5.3. Assessment of the research strategy

In this research both conceptual and constructive research approaches were used. The conceptual research approach was used to define the concepts, which were included in the ontologies for an organization's learning environment and knowledge creation activities. Testing of the developed concepts was carried out in different case studies. Based on the research results, it can be concluded that the developed ontologies are capable of describing the issues related to an organization's learning environment and knowledge creation.

The constructive research approach was used when building assessment systems for an organization's learning environment and knowledge creation activities. Different case studies were used to find out how the developed

constructs work in practice. In the case studies, the technical functionality of the applications was tested, the research results were validated and also the reliability of the research results was studied. On the basis of these results it can be concluded that this research presents a completely new approach to managing and leading the development of an organization's learning environment and knowledge-creating activities.

Also in this research were used analytical, systems and actors approaches. The analytical approach was used when studying general views of an organization's learning environment and knowledge creation activities based on different concepts. The systems approach was used when constructing a responsive environment for learning and knowledge creation. The meta-knowledge level of the Folium, Talbot and Lituus applications is based on this framework. The actors approach was applied when interpreting the results of the case studies.

5.4. Future research

In the future the main focus of research should be to repeat the study in some of the case study organizations. As a result of this research it would be easier to draw conclusions about how the Folium and Talbot applications could support the long-term development of the case study organizations. After multiple runs of the applications it would be easier to analyse what kind of effect different development activities have had, when issues related to learning and knowledge creation are discussed and practiced. This would facilitate the development and use of specific training modules. Repeated case studies would also support the further development of the construction of the Folium and Talbot applications.

Another interesting topic for further research is to use the Folium and Talbot applications in different areas of research besides learning and knowledge creation. Currently part of the Talbot and Folium applications are being used to study safety culture and sustainable development. This will provide many new opportunities for research, because learning and knowledge creation are essential parts of organizational development processes.

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APPENDIX: RESEARCH PAPERS

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Author's contribution: Co-wrote the introduction, theoretical framework and methodology of the research paper.

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