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Knowledge Support in Learning Operative Organisations

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Laajalahti, Espoo,
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early morning hours.

Summary

The aim of this study is to understand the requirements, critical success factors and outcomes of knowledge support, particularly in learning operative organisations. Initially, the work focused on support of individual employees performing individual work tasks, but it soon became evident that the perspective was too limited. First, it was expanded to cover smaller work units, and later the scope was extended to organisations.

This study summarises many years of work, starting in the early 1990s and concluding on present day. It is based on five constructivist case studies, four of which address knowledge support of employees and teams performing light-weight end-assembly tasks, and one which addresses organisational learning and knowledge management in project organisations.

The key findings include:

– Knowledge support system design and development requires system perspective, understanding that the system is an integral part of the work system and the work system may have to be re-engineered to accommodate the support system.
– User-centered design is essential for a successful knowledge support system, and this approach must include not only reader-users of the system but all the various user groups, particularly the author-users creating and maintaining the support content of the system.
– Improved organisational flexibility is one of the key goals and observed results of knowledge support systems. But in order to facilitate organisational flexibility, support systems need to be adaptable and tailorable in order to be able to react to rapid changes in the products, markets and the environment.
– Implementation is a particularly difficult stage of knowledge support system development. In several cases implementation has fully failed or it has had severe side effects.
– A knowledge support system can act as the technological infrastructure of a learning organisation. But in order to do this, a support system has to capture new knowledge created in the organisation in addition to distributing existing knowledge.

While the results of a study consisting of case studies have limited generalisability, the results can be considered mostly valid in the domain of knowledge support of assembly work tasks. The assembly line cases studied had several similar key characteristics. But when it comes to findings concerning knowledge support in learning organisations, one should be more careful. Nevertheless, even those findings were most fascinating and indicate interesting possibilities for further research.

The original papers

This dissertation consists of an extended summary and four appended papers:

Eloranta E., Mankki J. & Kasvi J.J.J. (1995) Multimedia and Production Management Systems. Production Planning and Control, 6(1), 2-12.

Kasvi J.J.J., Vartiainen M., Pulkkis A. & Nieminen M. (1997) Information tools for the shop-floor. AI & Society, 10(1), 26-38.

Kasvi J.J.J., Vartiainen M., Pulkkis A. & Nieminen M. (2000) The Role of Information Support Systems in the Joint Optimisation of Work Systems. Human Factors and Ergonomics in Manufacturing, 10(2), 193-221.

Kasvi J.J.J., Vartiainen M. & Hailikari M. (2003) Managing Knowledge and Knowledge Competences in Projects and Project Organisations. International Journal of Project Management. Accepted for publication.

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1 Introduction

Highly competitive global markets and development of new technologies have brought about radical changes to work organisations. While changes in the environment create new demands, new technologies and organisational forms bring new opportunities.

This turbulent period is creating new tasks and professions, but even the traditional tasks like manufacturing of cars and mobile phones demand new tools, practices, skills and knowledge. This revolution of working life comprises rapid changes in competency requirements.

New customer focused production paradigms that stress quality and flexibility and new technologies are just some of the factors that have increased knowledge and competency requirements of different work tasks. For example, in traditional line production people repeated frustratingly simple tasks over and over again, but on a high-tech assembly line it often happens that employees do not put together two similar products in a day. What is more, they often assemble the products from scratch and manage the operation of the line by themselves. Together, these factors may form an insurmountable proficiency overload. In such circumstances, training is not enough, and people cannot rely on their competences alone, but require efficient management of operative knowledge.

Corresponding situations can be observed in several other work settings, too. Work organisations need new knowledge and competency management practices and tools that facilitate these practices. Knowledge support or performance support, and corresponding computer systems offer one potential solution to these needs.

Figure 1. The revolution of work task requirements is well illustrated by the cockpit of a modern lumberjack with several computer and communication screens and control devices. Photos courtesy of Timberjack Group.

The traditional distinction between production work and knowledge work is becoming blurred. *Figure 1* shows a metaphoric image of this idea. The information and instructions we receive and act upon come more and more through machines rather than from observations of the real world. Now those machines are globally networked, and we have moved from the desktop into the world. We are witnessing an integration of media, people and communication. But people are not just passive recipients of information but actors, able to change and personalise the content of the information.

1.1 Background of the dissertation

Applications of information and communication technologies to support work task learning and performance with knowledge have been studied in the Helsinki University of Technology Laboratory of Work Psychology and Leadership since the early 1980s. The work started from development and study of computer based training systems and has evolved to support of learning work organisations (*table 1*). In the course of this work, three key developments have been observed.

Firstly, in the late 1980s, it became evident that the emerging information and communication technologies could be used for in task training. But until the early 1990s, the available multimedia technologies were so expensive and cumbersome that their practical training applications were limited. For example, the first mass-market digital cameras, high quality display drivers and sound cards became available during the first years of the 1990s.

Table 1. Research history behind this dissertation.

1970s	Critique of traditional work task training methods and practices.	e.g. Pöyhönen & al. 1982
Early 1980s	Development of task training and familiarisation methods. The Five Step Training method.	e.g. Vartiainen & al. 1989
Late 1980s	Development and study of a prototype *Computer Assisted Training System* (CATS)	Ollikainen & al.1991
Early 1990s	Development and study of another Computer Assisted Training System prototype (CATS!!)	Kasvi & al. 1993
Mid 1990s	Development and study of an operational support system for assembly-line work: *Interactive task support system* (ITSS) with ABB industry Oy.	Kasvi & al. 1994
Mid 1990s	Development and study of a Prototype information support system (ASIS) for marketing and maintenance.	Marttila 1995
Mid 1990s	Development and study of another operational support system for assembly line work: *Interaktiv Montagestøtte* (IMS) with Bang & Olufsen A/S.	Kasvi & al. 1996
Late 1990s	Study of implementation and use of a commercial information support system (Task Supporter).	Kasvi & al. 1997
Late 1990s	Study of *Information System for Assembly and Disassembly* (ISAD) A modular information system for assembly lines, including a support system for an assembly line work team.	Kasvi & al. 2000a
2001	Study of project organisation knowledge management and knowledge support needs.	Kasvi & al. 2003

Secondly, the 1980s and the 1990s marked a major shift in industrial paradigms. Or as one production line manager noted in the early 1990s when we tested our second Computer Assisted Training System prototype (CATS!!) on their assembly line: "A nice system, but we would have needed it five years ago. Today, we do not have time to train people anymore. We have to put them to productive work as soon as we hire them." What was needed in addition to training was on-site support.

Finally, even as our first support systems (ITSS, IMS) were designed to support individual assembly-line work tasks (for example, end assembly of a DC drive), it soon became evident that the scope was too limited. The perspective had to be wider. First, we focused on assembly-line work teams, and lately on operative work organisations.

1.2 The many names of support

Over the years, the terminology we have used to describe knowledge support and systems providing it has changed many times. Originally, while our focus was on supporting execution of individual work tasks, the terms used were Interactive Task Support and Interactive Task Support System (ITSS). The word interactive was used to stress the bi-directional nature of communication between the system and its user: in addition to delivering information, a support system should also collect it (Kasvi & al. 1996).

As our perspective expanded to cover work teams and organisations, the terms used were first Information Support and Information Support System (ISS) (Kasvi & al. 2000b). As the subject of knowledge management became better understood, these were soon changed to Knowledge Support and Knowledge Support System (Kasvi & al. 2003).

The most common term used in literature to describe corresponding systems is Performance Support (PS), and systems providing this support are called Performance Support Systems (PSS). If digital information and communication technologies are used to manage and deliver this support, the corresponding terms are Electronic Performance Support (EPS) and Electronic Performance Support System (EPSS).

The reason why we have chosen not to adopt the EPSS terminology can be found in the definitions used for performance support systems in literature from the early and mid 1990s. These definitions often stressed minimisation of need for learning or human support (see, for example, Raybould 1995 and Rosenberg 1995). In our view, information and communication technology should be used to facilitate learning and social interaction, not to minimise them (Kasvi & Vartiainen 2000).

Other related terms include Organisational Performance Support System (OPSS) that focuses on supporting the organisation instead of an individual and focusing on collaborative learning, as suggested by Bill (1997). In a Web-Based Performance Support System (WBPSS) and a Multimedia Performance Support System (MPSS), the technology used, the Internet or multimedia, is the main issue (see, for example, Brusilovsky and Cooper 1999, and Briggs 1996).

Interactive Electronic Technical Manual (IETM) is yet another, albeit more limited term. The term is most used in the U.S. military (see, for example, Kribs & al. 1996). Actually, an IETM can be used as a knowledge support system if it is accessible in a work context.

Job Performance Aid (JPA) and Job Aid are correspondingly wider terms, including all kinds of tools and systems that can be used to support work task execution (see Sleight 1994). If a Job Aid or a Job Performance Aid is computer-based, it is usually called an EPSS.

On-the-Job Training (OTJT) and Just-in-Time Training (JITT) are also often associated with knowledge support, particularly when information and communication technologies are used to deliver the training. While the idea of just-in-time training is to provide training when and where the competency in question is actually needed, on-the-job training is not necessarily bound by time but nevertheless takes place in an actual work environment. In literature, OTJT or JITT is often considered to form an integral part of a support system, and sometimes support systems are considered essential components of OTJT or JITT (see, for example, Cronjé & Baker 1999 and Collins & al. 1997).

1.3 The four studies

The four studies behind this dissertation have been published in peer-reviewed journals over the years. All of them have addressed issues related to knowledge management, particularly knowledge support in operative organisations. The organisations and settings have been different though, ranging from production management to assembly-line work to research and development projects.

The full texts of the studies can be found at the end of this dissertation, but short summaries have been included here for casual readers. Further discussion on these studies can be found in chapters 4 and 5.

1.3.1 Multimedia and production management systems

Eloranta E., Mankki J. & Kasvi J.J.J. (1995) Multimedia and Production Management Systems. Production Planning and Control, 6(1), 2-12.

While entertainment and educational applications of computer-mediated multimedia were already common in the early 1990s, industrial applications were still rare. Nevertheless, the opportunities for novel production management applications of emerging computing and communication technologies were already evident.

While emerging IC technologies provided the push for production management multimedia systems, the evolution of production management paradigms provided ‘’’the market pull required. During the previous few decades there had been three major waves in production planning control principles:

– MRP – Manufacturing resources planning
– JIT – Just-in-time

– LEAN – Lean (agile) production.

All three have been related to both the technology push of new data processing technologies and the amplifying market pull implied by new production management practices.

A lean factory is organised in teams. Communication is fast and continuous. The most important factor is to guide and support the decision making process. In such a team-organised environment, situations are examined, possible actions analysed and decisions made in a continuous process.

Lean information systems are needed for lean production management. Lean systems are decision support systems for professional users. Their information content is incomplete and even inconsistent in the traditional sense. The systems are planned around the decision-making processes of the teams. The detailed, bottom-up system concept with a preplanned solution to every situation gives way to the flexible, multimedia based communication and information environments, serving the principles of continuous improvement and learning organisation. The basic principle of lean ICT systems for lean production can be expressed as follows: "To apply human intelligence and interaction to simplify production management".

The study concludes with two case examples of multimedia production planning related systems. (1) Plantool is a workstation application for creating and maintaining production schedules. The system offers an interactive graphical user interface that allows the user to tune planning schedules by clicking and moving the objects on the screen. (2) Interactive Task Support is multimedia based information support system that utilises text, still video graphics and speech to deliver information needed in a lightweight assembly task. This information includes data on tools and materials and critical quality factors and detailed work instructions. Each work site has a multimedia capable workstation connected to a common network file server. The system is used not only to deliver but to collect task related information. The end users can edit certain parts of the documentation and write inquiries into an embedded notebook. This way, authoring becomes a continuous process, enabling the organisation to learn.

1.3.2 Shop-floor information tools

Kasvi J.J.J., Vartiainen M., Pulkkis A. & Nieminen M. (1997) Information tools for the shop-floor. AI & Society, 10(1), 26-38.

The study discusses an information technological tool, Interactive Task Support System (ITSS). The purpose of the system was to both train inexperienced employees and to support experienced assemblers with all the task related information needed during the completion of a complex lightweight assembly task.

The system was studied in two industrial settings, the DC drive assembly line of the ABB Industry Ltd. in Helsinki, Finland and the audio equipment production line of Bang & Olufsen A/S in Struer, Denmark. As the situation in the B&O case had been too turbulent to study in detail at that stage of the study, the conclusions were mostly based on the ABB case.

The usage of the ITSS changed when inexperienced trainees were turned into competent assemblers. The usage of the system diminished when an employee gained expertise, but it never ceased.

The users were heterogeneous in their media use. Some read all the texts some resorted to them only if everything else failed. Still video pictures were used as the most important information source. Actually, experiences with non-Finnish speaking test subjects indicated that even a major part of a complex assembly task can be completed without any textual information.

It was observed that the uniformity of the physical environment and the virtual environment within the support system is of paramount importance. Even minor differences like colour of a single component made some users think that they had made an error and prompted them to turn to other people for help.

The other observations included abolishment of paper documentation, increased flexibility of the work organisation, harmonisation of vocabulary and surprisingly low resistance to change.

A comprehensive performance support system can be regarded as the memory of the organisation. In fact, information management and support tools can be seen as the infrastructural basis for a learning organisation, as they enable individual and team learning processes: In addition to serving as an information source, a support system has to provide tools for reviewing existing knowledge and synthesising new knowledge.

Instead of just supplying information, a performance support system should provide a learning environment. It should provide interactions that enhance knowledge construction within the community of practice.

1.3.3 Information support and joint optimisation of work systems

Kasvi J.J.J., Vartiainen M., Pulkkis A. & Nieminen M. (2000) The Role of Information Support Systems in the Joint Optimisation of Work Systems. Human Factors and Ergonomics in Manufacturing, 10(2), 193-221.

Sociotechnical systems are adaptive and flexible if they have a certain amount of overcapacity, redundancy. The redundancy of a sociotechnical system is a function of its people (e.g. number, abilities and individual values), functions (e.g. goals and tasks), artifacts (e.g. parts and materials, information artifacts and tools), information and organisation (e.g. leadership, management, structure and organisational values).

Information supporting individual redundancy of functions can be extracted by interacting with four sources of information support:

1. One’s own memory consisting of declarative and procedural knowledge.
2. Social environment integrates cognitive, motivational, and emotional components with knowledge.
3. Physical environment consists of ordinary and computerised tools, parts and surroundings.

4. Information environment contains, for example, paper or computer based work instructions and manuals.

The definition of an information support system consists of four parts:
1. A source of information, supporting efficient, good quality, and safe completion of work activities.
2. Support is available on demand, in context with the task supported.
3. Information accessed spontaneously and the order of access in controlled by the end user of the information.
4. The system interactively supports the collection, creation, and synthesis of the experience-based knowledge of the members of the operative organisation.

The paper presents three examples of information support systems. All of them were designed to support complex light-weight end assembly tasks with hyperdocuments that contain text and still video pictures with optional CAD drawings, digitised speech and video sequences.

Two primary end-user groups were identified. Reader users used the information content to support their work and author users used the system to create this content. The roles were not completely separate, though, and reader users should be encouraged to input feedback and experiences into the system.

A successful introduction and implementation of shop-floor information support system requires three things:
1. A clear definition of the objectives
2. Solid cooperation between the developers and end-users
3. A change agent driving the project from conception to upkeep of the results.

1.3.4 Learning project organisation

Kasvi J.J.J., Vartiainen M. & Hailikari M. (2003) Managing Knowledge and Knowledge Competences in Projects and Project Organisations. International Journal of Project Management. Accepted for publication.

In addition to a product or service, projects produce technical, procedural and organisational knowledge. But while project organisations have become common, knowledge management of project organisations is underdeveloped. Nevertheless, project organisations require particularly systematic and effective knowledge management.

Table 2. A Project Memory System can be used to manage project knowledge. Its realisation and content depend on the knowledge management strategy adopted.

	Project Memory System	**Project Memory**
Codification strategy	Traditional and new information and communication technologies (e.g. documents, databases, email)	Explicit and declarative knowledge (e.g. specifications, instructions, definitions)
Personalisation strategy	Memory representations, personal interaction (e.g. mental models, dialogues workshops, seminars)	Tacit and procedural knowledge (e.g. competences, values, norms)

Two framework programmes and a review project were studied with interviews and questionnaires in order to understand:

– How do framework programmes manage knowledge?
– What knowledge management competences are required in framework programmes?

The observed codification strategy knowledge management practices were weak and unsystematic except for retrospective reporting. New knowledge was clearly created, but its accumulation and storage were unsystematic. Instead, the programmed relied on personalisation strategy. The greatest observed knowledge management competency needs were related to two knowledge management stages: knowledge distribution and dissemination, and knowledge utilisation and productisation.

Particularly systematic project knowledge management is needed, if results and lessons from one project are to be exploited in other projects. Some sort of a project knowledge repository and work practices that facilitate the use of this repository are being called for.

1.4 Structure of the dissertation

This dissertation consists of three main sections:

1. This introduction summarising and concluding the material presented in the four studies behind this presentation.
2. A supportive section consisting of an index and collected findings from the cases studied.
3. The four studies that form the basis of this dissertation.

Furthermore, this introduction consists of six chapters.

– Chapter 1 describes the structure and background of this dissertation.
– Chapter 2 discusses justification of this work and addresses the theoretical background influencing it.
– Chapter 3 identifies the research questions this dissertation aims to answer based on the material.
– Chapter 4 describes how this material has been collected and analysed.
– Chapter 5 reflects on the studies from the perspective of the research questions.
– Chapter 6 discusses the methodologies used and strives to place the results into a wider perspective.

2 Background

During the last few decades, business and society has become more and more turbulent. Both public and private work organisations have to become more flexible and agile, if they are to operate in this environment of continuous and unpredictable change (Goldman et al. 1995). One approach to flexibility improvement is organisational redundancy that can be attained either through redundancy of parts or redundancy of functions (Emery 1993 and Kasvi & al. 2000b).

This study focuses on redundancy of functions, particularly improving functional redundancy of the social element of the sociotechnical work system with knowledge support (*figure 2*). The discussion is rooted in a summary of 33 support system case studies found from literature.

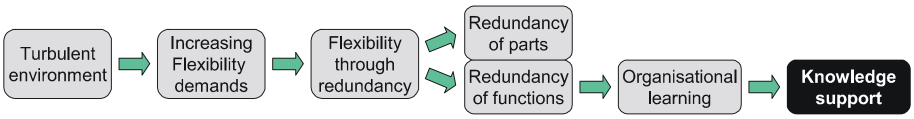

Figure 2. Flexiblity allows organisations to survive in a rapidly changing environment, and knowledge support is one way of improving that flexibility.

The chapter concludes with discussion on knowledge support system design and development.

2.1 Turbulent environment

Competency and knowledge requirements of the work place are increasing rapidly. Often this development is attributed to introduction of new product and production technologies (see *figure 3*), but technology is just one of the factors behind these developments. For example, new ways to organise work and people, and new business and production paradigms require employees to possess new competences. Principles like flexibility, agility and customer orientation have penetrated work organisations from strategic management to operative performance.

Marquardt (1996) lists four major areas, which have profoundly changed over the last years to influence work organisations:

1. Economic, social and scientific environment: Globalisation, economic and marketing competition, environmental end ecological pressures, new sciences of quantum physics and chaos theory (understanding of quantum physics means that one cannot predict with absolute certainty), knowledge era, societal turbulence.
2. Workplace environment: Information technology and the informated organisation, restructuring and resizing, total quality management movement, workforce diversity and mobility, boom in temporary help.

3. Customer expectations: cost, quality, time, service, innovation, and customisation.
4. Workers: Those who thrive will have problem identifier skills, problem solving skills and strategic broker skills. Corporations depend on the specialised knowledge of their employees. Knowledge workers do, in fact, own the means of production and they can take it out of the door with them at any moment.

Figure 3. Work desk of a modern storeman with several computer systems. Picture courtesy of GWS Systems.

As a result of these developments, such a thing as purely physical work has become more and more rare. Instead, the nature of work is changing from mostly linear to mostly non-linear and from requiring mainly physical skills to requiring mainly mental activity. Knowledge workers will soon outnumber physical labourers as the fundamental working class of modern societies. Work tasks that have traditionally been considered physically oriented include more and more knowledge work characteristics (Fisher & Fisher 1998).

Many empowered manufacturing teams on today’s shop floor make decisions that were previously reserved for middle-level management. Workers in these team-based operations set their own schedules, manage their own projects, rotate through multiple technical positions, hire their own team members, and participate in goal setting, peer evaluation, and daily management meetings. Even the most traditional factory work is rapidly shifting away from assembly-type linear work to non-linear physical work, or in many cases to knowledge work (*table 3*).

Table 3. Industrial trends affecting operations that traditionally have utilised physical work (Fisher & Fisher 1998, page 32).

Trend	Key implication
The automation of physical work	Remaining work is knowledge work
Work becoming increasingly complex	Workers need more technical knowledge
Unions more involved in decisions	Workers need more business knowledge
Increasing empowerment of workers	Workers spend more time on knowledge work rather than physical work

Traditionally organisations have answered to new competency requirements with task training and various job aids and documentation. But these traditional means are not always enough in the rapidly changing work environment, or as one production engineer commented: “It often happens that the assembly drawings arrive after the production of the product in question has ended.”

Organisations do not always have the time or resources to train their people at the same tempo products, services and organisations are changing. For example, production managers regularly face and solve situations they may have never met before; Assembly-line workers may manufacture several different products with hundreds of potential variations on a daily basis; People called to participate in multi-disciplinary product design and development teams may not have training or experience in design and development, but their input and participation is nevertheless sorely needed. As a result, employees often start their work tasks before their learning curve reaches acceptable competency levels (*figure 4*).

The growing need for workplace learning has occurred because of the changes caused by technology and the tremendous increase in global competition. Or as for example Marquardt and Kearsley (1998) point out, corporate training has increased at 30 times the rate of college education in recent years. Employees will need to train themselves, and training will no longer take place in a fixed time and location with a group of people for just-in-case purposes; instead, it will be implemented on a just-what’s needed, just-in-time, and just-where-it’s-needed basis.

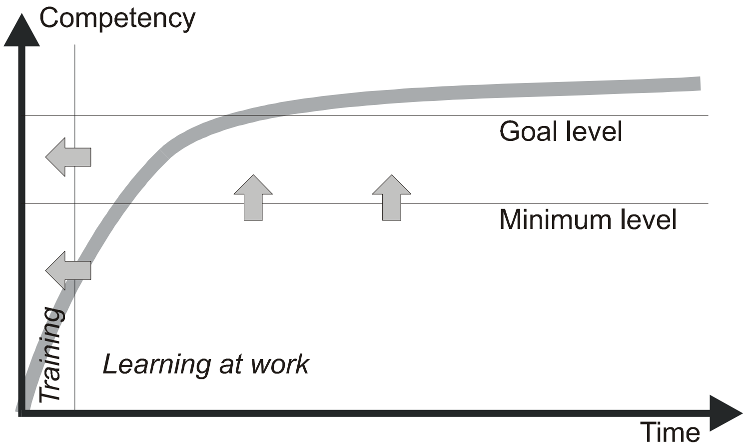

Figure 4. While time available for task training has diminished, competency requirements of many operative work tasks have increased. As a result, employees may have to execute tasks they are not yet fully competent in.

In order to thrive or even survive in such a turbulent activity environment, an organisation has to be very flexible. It has to be able to react rapidly to new threats and possibilities.

2.2 Four ways to flexibility

The key to organisational adaptability or flexibility is redundancy that according to the traditional sociotechnical approach can be improved either though increasing the number of parts or the number of functions of existing parts. But as work tasks have become more and more knowledge intensive, another perspective to flexibility becomes apparent: knowledge management.

2.2.1 Redundancy of parts and functions

A sociotechical system, for example, an organisation is a combination of a social and a technical subsystem, which are interconnected and interdependent (Emery and Trist 1960). In the traditional sociotechnical approach, organisations are viewed as adaptive and open systems (e.g. van Eijnatten 1993). Open systems interact with their environments moving from one technical and organisational structure and state to another (Mumford 1995, 1996).

A system is adaptive, if it has a certain amount of over-capacity, redundancy (e.g. Emery 1993). In the sociotechnical development approach, this redundancy can be attained either through redundancy of parts or redundancy of functions to the parts.

The redundancy of partsoption considers human beings as unifunctional, replaceable parts: redundancy is achieved through technology and extra people. The number of employees changes if production volume changes. New competences are brought in as they are needed. In practice, work systems relying on redundancy of parts in order to be flexible, can often be characterised as lean.

The redundancy of functionsoption regards the parts, people as multifunctional resources capable of having many skills and roles: redundancy is achieved through extra competences, functions. Employees are shifted from one task to another in order to adapt the organisation to temporal changes in production volumes. People have extra competences in order to be able to work in many roles.

A good example of these two approaches can be found from Kari & al. (1999) and Kasvi & al. (1999), where two technically similar Finnish semi-automatic assembly lines producing corresponding products were analysed with several different methods. Both lines were in their first months of operation, included work steps from pre-assembly to packaging, and employed some ten people (*table 4*).

Table 4. Selection of flexibility approach can have a profound impact on production system characteristics (Kari & al. 1999, pages 50-51).

	Anthropocentric case	**Lean case**
Number of parts in main assembly	About 20	5 to 6
Phase time	Up to 20 minutes	4 to 8 minutes
Pre-assembly	By main assembly workers	Mostly by subcontractors
Repair of defects	By main assembly workers	By specialised technicians
Employment	Thru' extensive pre-training	Worker pool
Team leader	Yes	No
Buffering	Active buffer plus separate buffers for each workstation	Traditional buffer of one to three pallets
Flexible routing	Yes	Limited, workstations tied to the main material flow
Flexibility through	Redundancy of functions	Redundancy of parts

While the flexibility of one of the lines was based on redundancy of parts (lean case), the other was designed to utilise redundancy of functions (anthropocentric case). For example, in task design this meant that people in the lean case received only rudimentary training and performed relatively simple tasks that did not vary. Flexibility was attained through changing the number of people working on the line. In the anthropocentric case, employees received extensive training and performed complex tasks that varied a lot. Flexibility was attained through moving people from one task to another.

Another interesting difference was found from information sources used to support task execution in each line. For example, the printed materials used by the people working in the lean case assembly line were limited to laminated work method A4's, while in the anthropocentric case, corresponding materials included work method flap boards, work instruction folders, escort cards, test reports, and repair instruction folders. What is more, the anthropocentric case was about to receive an intranet based knowledge support system.

In spite of the fact that the sociotechnical approach preaches the affinity of the social and the technical organisation, it has divided organisations into definitely social and technical subsystems. Through technological developments this division has become more and more artificial. Or, as Banerji (1999) notes, work is done neither by people nor by computers but by human-computer systems. People and technologies interact and even merge to form new kinds of a work systems, whose "parts" are not mere people but entities consisting of people and their technical artefacts. These parts can have redundant functions, and the sociotechnical system can have functional redundancy, both through individual competences and information technological artefacts supporting these competences.

2.2.2 Two knowledge management strategies

Knowledge management (KM) has become one of the key activities of private and public organisations, as the basis of economy has shifted from utilisation of natural resources to application of knowledge assets. But while KM is widely discussed[1], it has no established definition, and some authors even refuse to use the term (see, for example, Barth 2000). This study adopts a process-oriented perspective on knowledge management, which is considered to consist of organisational practices, processes and technologies used to gather, develop, organise, distribute and utilise knowledge.

Organisations utilise two basic strategies for knowledge management (Hansen & al. 1999). The codification strategy is based on codifying the knowledge and storing it in artefacts and databases where it can be assessed and used over and over again. These technical repositories contain typically "hard" data, for example, database records, documents, and standard operating procedures.

In the personalisation strategy the knowledge is closely tied to persons who developed it (people as repositories) and is shared by personal interaction. The content of these repositories are mainly "soft" items like stories, recollections, and details of a decision making process.

Davenport and Prusak (1998) offer a good example of the personalisation approach. While their organisational knowledge management model consists of the traditional three elements (Knowledge generation, knowledge codification and coordination, and knowledge transfer), they contain elements like personnel acquisition and informal communication.

As the main focus and investments in knowledge management are usually concentrated on ICT tools and explicit knowledge (codification strategy), the personalisation strategy often needs strengthening.

2.2.3 Combining redundancy and knowledge management

By combining the two approaches to organisational redundancy and the two knowledge management strategies, we can create a two-dimensional field for classification of different ways to improve organisational flexibility (*figure 5*). Selection of the most appropriate approach from this field is a highly sensitive selection that reflects both the situation and the values of the people involved.

[1] For example, the Google search engine found on August 29th 2002 935,000 web pages with the phrase "knowledge management".

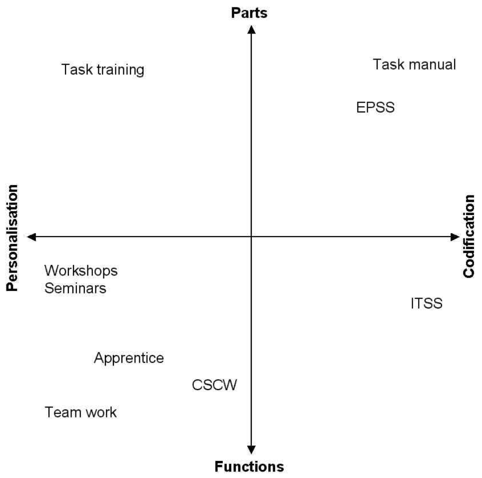

Figure 5. The four approaches to improve organisational flexibility through improved knowledge management.

2.3 Perspectives on learning

Managing knowledge is not enough. In order to be of use, knowledge has to be applied to practice by people. That is, they have to learn.

Learning has become a lifelong process. The traditional way of learning has been to bring students together for lectures that occurred in one's early years. Now learning is all-the-time, everywhere, yet just-in-time and customised just-for-you. We must now train ourselves, take the responsibility and develop the competences of self-directed learning. Learning has become the most important part of everyone's job.

2.3.1 Learning models

In order to discuss learning models, first we have to define learning. There are three fundamentally different ideas about the nature of learning, that is, how learning occurs, These three are behaviourism, cognitivism and constructivism. (see, for example, Ertmer & Newby 1993 and Andersson 1980)

Behaviourism is based on behavioural changes. The basic principle is to repeat and reinforce a new behavioural pattern until it becomes automatic. Behaviourism observes behaviour without referring to mental processes behind it. Learning is a passive process, where learner reacts to different stimuli (cues), for example, given knowledge.

Cognitivism focuses on the mental processes behind the behaviour. Human mind is seen as an information-processing system that commits abstract symbolic representations of given knowledge to memory, where they may be stored and processed.

Constructivism sees learning as an individual knowledge construction process. Knowledge cannot be given as such, but it will have to be (re)constructed by each learner. Therefore, learning results are based not only on given knowledge but on learners' prior experiences and schema. Furthermore, there are two main schools of constructivism. While cognitively oriented constructivists stress individual exploration and discovery as a basis of learning, socially oriented constructivists emphasise collaboration and interaction of learners.

Table 5. Characteristics of the three prevalent learning theories.

	Behaviourism	Cognitivism	Constructivism
Main contributors	Watson, Skinner and Bandura	Dewey, Piaget and Bruner	Vygotsky
Basis	Behavioural psychology	Gestalt psychology	Gestalt psychology and cognitivism
Knowledge	Given and absolute	Given and absolute	Relativistic and fallibilist
Focus	Observable behaviour	Mental processes	Personal or shared problem solving
Learning	Passive automatisation of repeated behaviour	Active mental processing of mental constructions	Individual or collaborative knowledge construction
Instruction	Repetition of stimulus and reward for desired reaction	Presentation of relevant information.	Preparation of the learner to construct the desired knowledge

2.3.2 Learning at work

Support of work task learning can be divided into three groups depending on the temporal relation between the work task and delivery of supportive knowledge: (1) training, (2) support, and (3) feedback. These groups correspond with the action regulation theory (Hacker 1973) that divides human actions to three phases: (1) orientation (design of action programs, decision making), (2) execution, and (3) control (supervisory activities, use of feedback) (*figure. 6*). So, in order to support work action from beginning to end, all three should be addressed.

Training happens before work task performance and may consist, for example, of lectures and exercises. In present turbulent work environment training is not always a sufficient solution as work tasks and competency requirements change too fast. What is more, the content has to be comprehensive, that is, answer to all the potential knowledge and competency requirements the trainee may face at work.

It should be noted that training is focused on the learner's present job, as stressed for example by Dubois (1993). This places training apart from Education that focuses on a future job of the learner and Development that is not focused on any particular work task (Dubois 1993).

Support takes place during task performance in task context. While trainer defines the content of training, it is the learner, an employee, that decides, what knowledge he or she needs in a given work situation. As support is available when needed, the employee does not have to remember everything by rote.

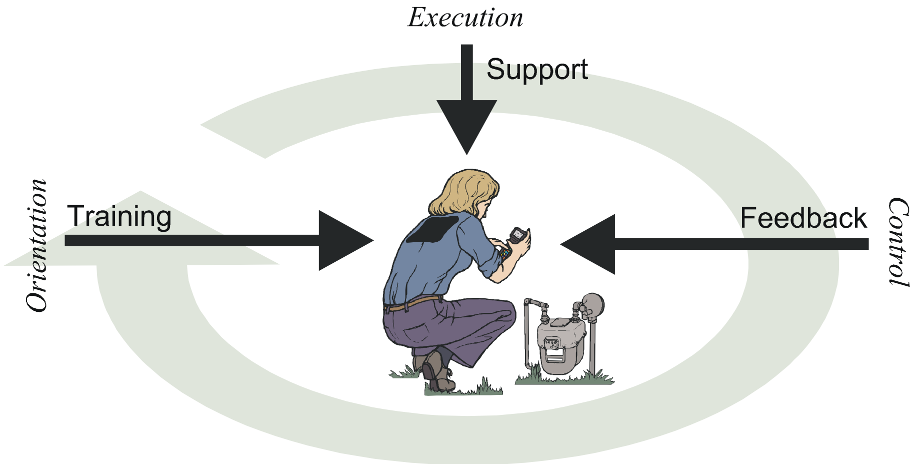

Figure 6. Methods and tools facilitating learning in work task context can be divided in to three groups depending on their temporal relation to work task performance. These three groups correspond with the three stages of human actions.

Feedbackis provided after work task performance. This way it can respond to observed competency problems. The delay between the performance and the feedback should not be too long, though. Quality control systems are typical examples of feedback supporting learning.

It should be noted that according to many studies, most efficient learning happens when training is embedded in work processes (Raybould 1995, Huber 1998).

Table 6. While training, support and feedback may be provided by the same system, they have some fundamental differences. Adapted and expanded from Gery (1991) and Kasvi & al. (1997).

Training	**Support**	**Feedback**
Knowledge is delivered before the task.	Knowledge is during the task.	Knowledge is delivered after the task.
Either in or separate from task context.	Embedded into task context.	Either in or separate from task context.
Medium to long range goals.	Instant goals.	Short to long range goals.
Based on assumed information needs of the trainees.	Answers to employees' personal knowledge needs.	Answers to employees' observed competency deficiencies.
Trainer defines content.	Employee defines content, or the system observes the employee and deduces, what is needed.	Quality system defines content.
Trainees should not forget what they have learned.	Users can check on things if they are unsure.	People should not forget what they have learned.
Static environments and basic skills.	Dynamic environments and skill application details.	Skill performance feedback.

2.4 Learning organisation

Employees' individual learning is of course important, but it does not necessarily improve performance of the organisation they work in. If organisation itself does not learn, that is, integrate new knowledge learned by its members and change its ways of action accordingly, individuals working within the organisation may not be able to exploit the lessons they have learned.

Organisations that are able to learn faster will be able to adapt quicker and thereby achieve significant strategic advantages. This new species of organisations is called a learning organisation, and it possesses the capability to (Marquardt 1996, page 2):
- Anticipate and adapt more readily to environmental impacts
- Accelerate the development of new products, processes, and services
- Become more proficient at learning from competitors and collaborators
- Expedite the transfer of knowledge from one part of the organisation to another
- Learn more effectively from its mistakes
- Make greater organisational use of employees at all levels of the organisation
- Shorten the time required to implement strategic changes
- Stimulate continuous improvement in all areas of the organisation.

There have been many attempts to define a learning organisation, and as Virkkunen and Kuutti (2000) point out, the theory of learning organisation is still fragmented and lacks practival value. The most well known definition is that of Senge (1990, page 3), who defines a learning organisations as "Organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to learn together." In addition, Senge lists "five disciplines" that are the keys to achieving this type of organization: personal mastery, mental models, shared vision, team learning, and most importantly, systems thinking.

Adoption of the learning organisation paradigm requires organisations to rethink their basic ideas (see *table 7*). While the need to acquire more knowledge will continue, but what people and organisations know takes second place to what and how quickly they can learn. Learning skills will be much more important than data. A learning organisation has the capacity to collect, store, and transfer knowledge and thereby continuously transform itself for success.

Table 7. The seven key paradigm shifts that make a learning organisation different from the traditional organisation (Marquardt & Kearsley 1998, page 29).

Traditional focus	Learning organisation focus
Productivity	Quality of performance
Workplace	Learning environment
Predictability	Systems and patterns
Training	Learning
Worker	Continuous learner
Supervisor/manager	Coach and learner
Engagement/activity	Learning opportunity

2.4.1 Perspectives to organisational learning

Organisational learning takes place when new routines and ways of action are conceived and adopted in an organisation through individual learning and group dialogue. These routines and ways of action are not dependent on the individuals and groups that have created them but survive even after the people involved have left the organisation.

According to Marquardt (1996), learning in organisations can occur at three levels. Individual learning is needed since individuals form the units of groups and organisations, or as Senge (1990, page 139) asserts “organisations learn only through individuals who learn”. The factors that can contribute to individual learning in the organisation include:

- Individual and collective accountability for learning
- Locus and focus of individual learning (learning should have immediate application to the job.)
- Accelerated learning techniques.
- Personal development plan (people recognise that employers cannot guarantee them lifelong employment but that they can assist them in achieving lifelong employability. There should be a partnership between the organisation and the employee to assist in the long-term career development.)
- Abundant opportunities available for professional development
- Individual learning linked to organisational learning in an explicit and structured way.

Group/team learning means that work teams must be able to think and create and learn as an entity. They must learn how to better create and capture learning (learning to learn). A successful team learning system ensures that teams share their experiences with other groups in the organisation. Team learning will occur more fully if teams are rewarded for the learning they contribute to the organisation. Marquardt uses Watkins and Marsick’s team learning model that shows the learning organisation as the union of individuals and organisation. The key is the overlap, which is where teams function.

Organisational learning (1) occur through the shared insights, knowledge, and mental models of members of the organisation, and (2) builds on past knowledge and experience which depends on institutional mechanisms (policies, strategies, explicit models...) used to retain knowledge. Though organisations learn through individuals and groups, the process of learning is influenced by a much broader set of variables (for example, the performance of a symphony is more than the sum of individuals’ knowledge and skills but the result of the know-how embedded in the whole orchestra working in unison).

Another, problem focused perspective to organisational learning is offered by Argyris and Schon (1978), who identify three different levels of organisational learning.

- In single loop learning an organisation learns when it observes an error and corrects its, but does not change its policies, objectives or thinking models.
- In double loop learning an organisation learns by correcting observed errors in a way that involves the modification of organisational norms, policies and objectives.

– In deutero learning, members of an organistion reflect on and inquire into organisation's previous contexts and experiences for learning. Based on these reflections, the organisation and its members learn to learn, understand what facilitates or inhibits learning and invent new approaches for leaning.

The problem with Argyris' and Schon's (1978) levels of organisational learning is that that they are reactive. They require a stimulus, and learning is a response to that stimulus. In order to be proactive, a learning organisation should be able to create, acquire and transfer knowledge and change its behavior accordingly (for example, Sarala 1993)

But as Raybould (1995) points out, discussion on learning organisations has been weak on practicalities. What kind of practical mechanism would best support both individual and organisational learning? Raybould (1995, 2000) proposes an Organisational Performance/Learning Cycle (*figure 7*) as a basis for a conceptual framework for thinking about how people learn and perform in an organisation. This Cycle has five phases:

1. During Performance-centered design a knowledge base is structured and an interface created to present the knowledge to users.
2. Performance is achieved through the use of the system.
3. Individual Learning (of existing knowledge) happens as a result of performance supported with the system.
4. Generation of new knowledge happens in the course of performing work when the user develops new techniques, methods and procedures.
5. Knowledge Capture of the additional knowledge gained by individuals and teams in the course of performing their work is essential for organisational learning.

Organisational learning takes place when this loop is completed, and the knowledge captured in phase five is integrated into the knowledge base structured in phase one.

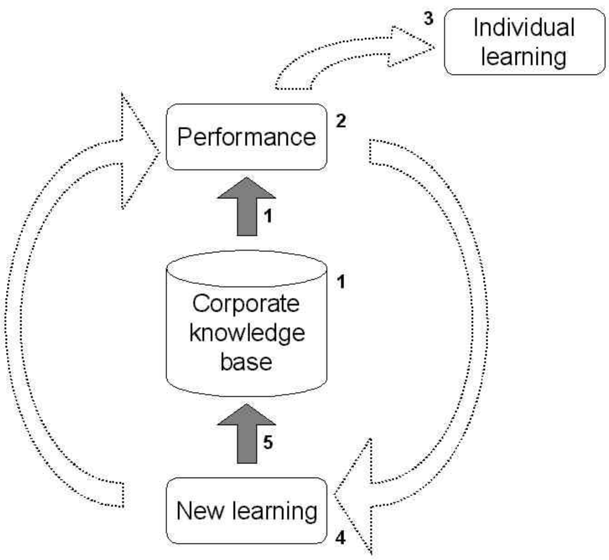

Figure 7. Raybould's (1995, 2000, page 4) Organisational Performance/Learning Cycle.

While Raybould's Cycle is limited to encoded knowledge and codification based knowledge management strategy (see subsection 2.2.2), it can act as a technological basis for a system that facilitates organisational learning.

2.4.2 Remembering organisational knowledge

Operative organisations have several potential outputs, not all of which are intentional or intentionally managed:

- A product or a service provided and delivered for an internal or external customer.
- Different kinds of knowledge related to the product or service or the organisation:
  - Technical knowledge concerning the product and its production and use.
  - Procedural knowledge concerning the procedures to produce and to use the product.
  - Organisational knowledge concerning the organisation itself.

Organisational knowledge is particularly important for organisational learning. If the organisation fails to systematically capture it (see *figure 7*) it risks repeating its errors over and over again and losing any learning possibly taking place. Organisational knowledge is based on the good and bad experiences of organisation members, team leaders and managers when they have successfully or unsuccessfully solved problems at hand and completed their tasks. But the negative experiences are easily forgotten, and people don't usually have enough time to handle and reflect on the positive experiences.

Organisational memory is used to define (1) the organisational knowledge and (2) the processes by which this knowledge is managed. This duality can be underlined by two outwardly similar but fundamentally different definitions of organisational memory: While Walsh and Ungson (1991) define organisational memory as stored information from an organisation's history that can be brought to bear on present decision, Stein and Zwass (1995) define organisational memory as the means by which knowledge from the past is brought to bear on present activities. The difference lies in the focus of the definitions: Walsh and Ungson concentrate on the memory content and Stein and Zwass on the memory system.

Organisational memory is distributed throughout the entire organisation in individuals' knowledge representations and competences and the Organisational Memory System may store it in various forms, for example, as databases, writings, stories, learning histories and as memories in people's minds.

The technologies and methods people use to realise an Organisational Memory System may be very simple like a shared paper folder or they may apply state-of-the-art information and communication technologies depending on the needs and facilities of a particular organisation. Electronic document management systems, electronic performance support systems and knowledge support systems, the subjects of this study, are typical examples of such technologies. But in order to form a core of an Organisational Memory, these systems have to accommodate all the levels (e.g. individual, group and organisation) and stages of organisational learning (for example performance, individual learning, creation of new knowledge, knowledge capture) discussed above (see *figure 8* for an example).

Actually, an Organisational Memory System, or EPSS, or whatever, should be able to handle two distinctively different kinds of knowledge. It should cover both substance and lessons learned, what was done and how it was done. It is not enough that an organisation collects, stores and distributes technical and procedural knowledge according to traditional knowledge management principles. The way this knowledge was obtained should be stored as well. There are practices that work and things that do not work in a particular situation. The organisations involved should be able to utilise these experiences, this organisational knowledge in their future projects. If these lessons are not stored for future use, the organisations cannot understand what actually happened and why. They effectively forget what they have learned and cannot become learning organisations.

But if the experiences are captured only as documents and other knowledge artifacts, the contexts and the processes behind the documents is lost (Conklin 1993). Both codification and personalisation knowledge management strategies (see subsection 2.2.2) are needed in order to comprehensively manage different kinds of knowledge in operative organisations.

In spite of the fact that knowledge support and knowledge management is much more than technology, technology is an integral part of it. Technology's most valuable role is extending the reach and enhancing the speed of knowledge transfer (Davenport & Prusak 1998). Technology also helps in the codification and even in generation of knowledge.

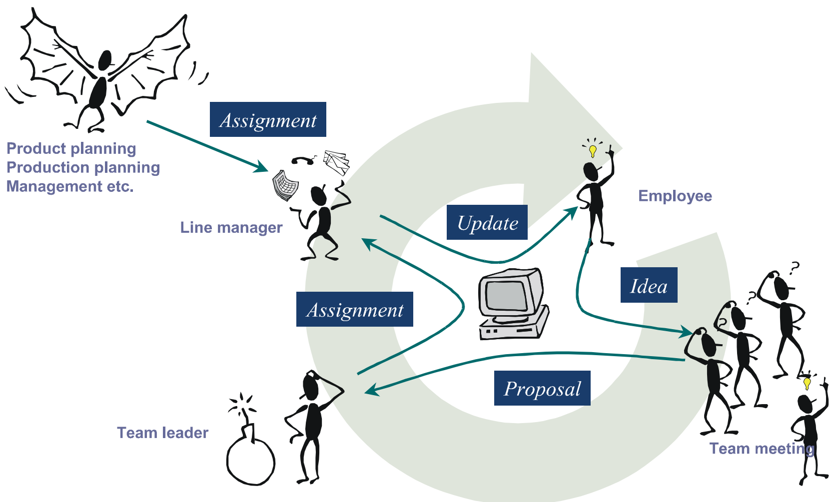

Figure 8. An example of a social system facilitating organisational learning within a work team. At the center of the system is a technological system supporting the social system, for example, a computer supported cooperative work system or a knowledge support system acting as an organisational memory system.

Davenport and Prusak (1998) point out that since it is the value added by people, context, experience, and interpretation, that transforms data and information into knowledge, it is the ability to capture and manage those human additions that make information technologies particularly suited to dealing with knowledge. Knowledge technologies are more likely to be employed in an interactive and iterative manner than, say, data management technologies. Therefore, the roles of people in knowledge technologies are integral to their success.

But supporting an individual or even a group to execute a work task with technology is still simple when compared to extending the concept of knowledge support to cover the whole organisation: “In order to support organisational learning, you have to address the whole operative organisation. As informative support has traditionally been targeted to individual people or groups, in a learning organisation we have to face the whole organisation in context” Kasvi & al. (1999, page 201).

2.5 Knowledge support

Davenport and Prusak (1998) conclude that what makes a company a learning organisation is 1) its capacity to have its people learn faster and better and 2) its ability to effectively manage knowledge. Technology is absolutely necessary to accomplish each of these functions. Or as Marquardt and Kearsley (1998) propose, knowledge support, or EPSS, as they prefer to call it, can provide a valuable info-structure for building a learning organisation. Raybould (1995) agrees, seeing an EPSS as the enabler of a learning organisation.

In order to thrive, that is, to learn and to adapt in these conditions, work organisations require knowledge tools that complement the requirements and abilities of their operative personnel. In addition to distributing knowledge to the work context, these tools should support knowledge creation, collection and development, if they are to facilitate organisational learning (*figure 9*). Developing such operative knowledge management tools is a challenging task that requires a combination of different kinds of competences. The designers of such tools have to take into account the requirements and limitations set by the people using them, the knowledge managed with them and the work tasks supported with the knowledge.

The knowledge managed with these tools is required elsewhere in the organisation, too. For example, an assembly line produces lots of valuable information on manufacturability and costing that could and should be utilised elsewhere in the organisation.

Fortunately computer and communication technologies have evolved during recent years so that they can be used to address this challenge. There are already several examples of very useful information systems that gather, manage and deliver required pieces of knowledge directly to the work situation. Unfortunately not all such operative information systems have been successes. There are also several such information systems that actually hamper work task performance.

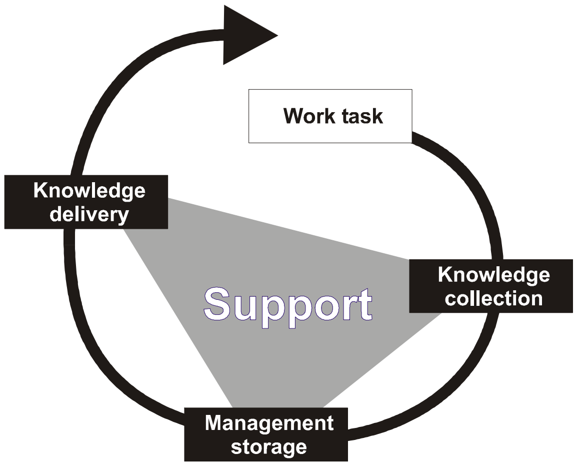

Figure 9. It is not enough to deliver the needed piece of knowledge to the work task performer.

Gloria Gery, an acknowledged authority in the field of computer based training, noticed in the late 1980s that training given prior to a task was not any more able to satisfy the various competency requirements of present day work environments. At the same time, computer technologies had developed rapidly and in the late 1980s possibilities like multimedia and local area networking emerged to widespread use. Putting these pulls and pushes together, Gery devised a totally new paradigm she called electronic performance support systems or EPSS for short (Gery 1991).

While the concept of EPSS was born in the United States a decade ago, and there are many successful case histories in North America, in Europe there have been only a few implementations of EPSS and the whole approach is almost unknown (Ceroni 2001). Ceroni identifies two main reasons behind Europeans' lukewarm reception of performance support: Different industry requirements and different cultural and social environment. In Europe there is a cultural (and often even legal) aversion to measuring or tracking individual performance. This dilemma is discussed in more detail in subsection 6.4.3.

Development and utilisation of support tools and methods has been closely tied with development of information and communication technologies:

– 1970s and before: Separate, non-computerised support, for example, paper documents, job aids, model dummies, task training, phone support (help-desk) and programmed learning.
– 1980s: Linked, computer-based support, for example, on-line-help, on-line-documentation, computer-based training and expert systems.
– 1990s: Embedded computer-based support, for example, electronic performance support systems (EPSS), product data management, wizard-functionalities and context-sensitive help
– 2000s: Transparent, interactive support, for example embedded, transparent support, mobile support and interaction with other people instead of a computer (teamware).

Table 8. Both users' and tasks' characteristics influence potential utility of a support system (adapted from Banerji 1995).

User characteristics	Task characteristics
– Staff turnover is high – Employees need to achieve high levels of proficiency very rapidly – High cognitive load – Wide range of user capability (knowledge level and task responsibility)	– Infrequently performed tasks – Tasks involving large amounts of information – Tasks involving multiple steps and parts – Applications or procedures that involve extensive functionality – Tasks requiring diverse knowledge

The potential utility of an EPSS depends upon the characteristics of both the people supported and the tasks supported. Banerji (1995) lists several, mostly knowledge intensive work situations where an EPSS may be an attractive solution (*table 8*).
It should be underlined that not all support systems are computer based or even electronic. Too often, discussion focuses on technologies used and the knowledge managed with these technologies and the organisational implications are forgotten. Or as Harmon (1999) stresses, the word "system" is more important in electronic performance support systems than the word "electronic".

A comprehensive support system brings together different kinds of support from informal human support to well-defined electronic documentation (Sherry & Wilson 1996). One size does not fit all, that is, all forms of support have their strengths and weaknesses, and over-reliance on one type of support may leave the whole lacking in some respects.

Table 9. Key resources for comprehensive performance support (Sherry & Wilson 1996, page 31).

Support	Examples	Strengths	Limitations
Designed messages and experiences	– Documentation – Training and instruction – Simulations – Web pages	– Conveys information well – Good peer review – Quality control	– Expensive to produce – Difficult to keep updated – May require specialised hardware/software
Information tools and resources	– Information databases – Procedural aids – Online help – Quick references – Search tools	– Flexible user control – Easy to construct and maintain – Specific and detailed – High-level expertise – Timely – Easy to keep up-to-date	– Information overload – May not be presented well – Variable quality – May not match user's needs
Informal human support	– Primary workgroup (office, team. cohorts, family, etc.) – Specialised support groups (online support groups, self-help groups, users' groups, SIGs, clubs, etc.)	– One-on-one mentoring – Backup support, helping where other supports fail – Local expertise – Motivational support – Group identity – Quick response time	– Resource intensive – Variable quality – Limited presentation capabilities – Lack of access

While the overall context for development of a knowledge support system is to improve job performance, the use of such systems tends to actually redefine the nature of work activities. Once people realise that a support system can allow people to accomplish a lot more, they start to develop/request more sophisticated on-line capabilities. Job responsibilities and roles change because a given individual is likely to be able to carry out a more diverse range of tasks, with more competency. Support system designers should know what changes in job performance they wish to achieve.

2.5.1 Definition

Early definitions of knowledge support or performance support reflected traditional organisational paradigms. Support was provided for a single recipient at a time, and the information content of the system was static and authored by someone organisationally separated from the recipients of the support. For example, Reynolds and Araya (1995) see performance support systems simply as electronic job aids, and the performance support pioneer Barry Raybould (1990) defines an EPSS as “an electronic system that provides integrated, on-demand access to information, advice, learning experiences, and tools to enable a high level of job performance with a minimum of support from other people”.

But as organisations and their environment changed, the limitations of these early definitions became soon apparent. For example, Raybould (1995, page 11) has revised his definition to reflect systems thinking, essential to organisational learning: "An EPSS is the electronic infrastructure that captures, stores, and distributes individual and corporate knowledge assets throughout an organisation, to enable individuals to achieve required levels of performance in the fastest possible time and with a minimum of support from other people".

Another revision, introducing on organisational perspective, is offered by Bill (1997, page 6): Organisational performance support system, OPSS, is “an electronic infrastructure that captures, stores, organizes and distributes individual and corporate knowledge assets throughout an organization and enhances communication to enable an individual and the organization, to transform existing behaviour in order to achieve performance objectives in the fastest possible time.”

Yet another important extension is offered by Laffey (1995, page 31), who extends the idea of an EPSS with the concept of dynamism: "Dynamic support systems are characterised by the ability to change with experience, the ability to be updated and adjusted by the performer, and by augmenting other supports found in the performer's community".

Finally, as if to summarise all the definitions presented above, Raybould (1995, page 21) concludes by proposing a new definition of EPSS as “the electronic infrastructure that enables the learning organisation”.

While illuminating, Raybould’s (1995) conclusion is too unspecific and wide for our purposes. A more detailed definition of a system providing comprehensive knowledge support consists of four parts (Kasvi & al. 2000c, page 29):

– A source of information, supporting efficient, good quality and safe completion of work activities.
– Support is available on demand, in context with the task supported (*figure 10*).
– Information is accessed spontaneously and the recipient of the information controls the order of access.
– In addition to providing information, the system interactively supports the collection, creation and synthesis of the experience based knowledge of the members of the operative organisation.

Figure 10. This knowledge support system used in the Nokia base station plant in Oulu illustrates, how support is brought directly into work context. Picture courtesy of Nokia Networks.

2.5.2 Different kinds of knowledge support

The actual form and functionality of a knowledge support system depends on the work and people supported. For example, a simple memory aid may suffice for a simple and stable assembly task but complex tasks like maintenance of the assembly equipment may require detailed work method descriptions and a base of real life maintenance cases augmented with communication tools that allow consultations with human experts. In use, the system tells less-experienced users the best solution to a problem. Experienced users may question the system's recommendations.

A support system may be active or passive. While an active support system monitors the employee's progress and the production process and provides information that the system deduces to be needed, a passive support system, waits for employee's requests for information (*table 10*).

Table 10. An active support system can monitor both employee's progress and the work process (Kasvi & al. 2000c, page 41).

		Monitors actively employee's progress	
		No	**Yes**
Monitors actively work process	**No**	Printed manual of a computer program	Task trainer
	Yes	Escort card	Experienced colleague

Banerji (1995) categorises support systems according to the nature of the task supported:

1. Systems intended for software support.
2. Systems designed to support computer-based tasks.
3. Systems intended to support non-computer-based jobs.

Another important distinction can be made based on the level of integration of the support system with the task supported. Gery (1995) distinguishes between three basic types of support:

– Intrinsic support (or embedded) is so integrated with the underlying application that from the end user's point of view it can be regarded as part of the application itself. For example, a wizard (there may also be extrinsic wizards that the user has to invoke as stated by Gery 1995).
– Extrinsic support (or linked) is also integrated into the application but the user must break task execution in order to access support. For example, Windows Help.
– External support (or separated) is not integrated with the application and requires a user to break the work context and access something that is clearly separate from the target application. For example, a printed user manual or help desk.

The recommended design principle is to make support as intrinsic as possible. Or as Bezanson (2002) notes, support can often be implemented by building into products various performance-enabling features. Those aspects that cannot be built in, can be taken care of with a specific support system. Of course, if the tasks supported are not conducted with a computer, only external support is possible.

Capabilities provided by a support system depend on its realisation and application area. For example, a wizard may be very useful for tasks involving computer applications, but has no application on a system supporting maintenance tasks. Examples of typical support system capabilities include (see, for example, Reynolds & Araya 1995, Ockerman & al. 1996, Leighton 1996 and Gery 1995, classification follows principles suggested by Miller 1996):

– Source of information the employee needs to perform a task. The repository of this information is often called an information base.
  – Reference information, for example, case histories that the users may occasionally need.
  – Work method instructions, for example, a list of subtasks or a simulation of the work task.
  – Cue cards provide hints and tips on important task details.
  – On-line help is a reactive advisor that aids users of a computer system over problems.

  - Task-specific, just-in-time training, for example, tutorials and simulations allow users to study and learn. The learning experience occurs while the work is being done, not in a separate context.
  - Tracking and feedback tracks task execution in order to provide feedback.
- Simplification of the task.
  - Tools that support execution of actual work tasks, for example, by automating routine calculations.
  - Wizards and templates guide users through tasks summarising choices and conditions and suggesting recommended procedures.
  - A coach is a proactive advisor, providing guidance in goal setting and task monitoring.
- Decision support that enables the employee to identify appropriate action in a particular situation.
  - Advisors and decision support systems guide users when they analyse and evaluate a situation and help them to make decisions.
  - Expert systems provide specific advice for specific needs.
- Other.
  - Self-assessment of performance.
  - Knowledge collection and development tools are used to accumulate and manage knowledge content for the support system. Such tools may be used, for example, to gather case histories describing, how the users have approached and possibly solved problems.
  - Communication tools support communication needed at work and delivery of new knowledge created.

When CBT Solutions magazine in 1996 made an inquiry into types of EPSS used in the United States, 639 of 10,000 questionnaires were returned. While the sample used in the survey is small and far from representative, the results illustrate the great diversity of the approaches support system developers use (*table 11*).

Table 11. Support systems may apply very different methods. The CBT Solutions magazine survey in 1996 indicates that eight types of support were used in 100 or more of the 639 organisations that had completed and returned the questionnaire (Benson 1997).

Support method	Number of organisations using the method
Reference information with search functions	216
Explanations	200
Context dependent help	186
Demonstrations	140
Interactive instructions	136
Tool hints	135
Context independent help	136
Work method instructions, wizards, coaches	117
Application presentations	77
Cue cards	77
Screen tours	68
Other	25

2.5.3 Reader and author users

Knowledge support systems have two primary user groups, each of which should be taken into account in support system design. In many knowledge support systems there are two separate user interfaces for these two groups.

Reader users or end users, as they are also called, use the system to support their work performance. They are typically operative personnel, for example, repairmen or bank clerks. In many cases they do not possess previous experience in computer system use, and may have negative bias to computers. Introduction of new computer systems should therefore be planned carefully in order to avoid negative first impressions.

Author users create and maintain the information content of the support system. They are typically trainers, foremen, or production planners. They should have a very good understanding of the people and tasks supported and the environments where they are performed. In many cases, authoring does not take place in connection with the tasks supported, and the author users are not familiar with the everyday problems encountered.

These two roles are not always clearly divided, as people using a knowledge support system to support their work may also contribute to its information content. Actually, such mixing of roles is essential for continuous improvement of the system and the support it provides.

2.5.4 Related information systems

Knowledge support is just one of many new applications of technology that influence work performance and learning. Often the actual computer systems introduced to operative organisations combine characteristics and functionalities of various different systems, and it may be difficult to say, where knowledge support ends and for example knowledge management or computer-based training begins.

Sherry and Wilson (1996) list several information systems and disciplines that are closely aligned with performance support, including computer-supported collaborative work (CSCW), technical communication (TC) of just-in-time just-in-place information, and electronic publishing. According to them, all of these systems actually provide performance support and have two shared concerns even if emphasis may vary:

– Instruction and learning: Creating environments, products, and processes to support new learning
– Information conveyance: People can perform well when they have the information they need in a timely and understandable manner.

Computer-supported collaborative/cooperative work (CSCW) systems and groupware systems facilitate synchronous and asynchronous cooperation regardless of collaborators' physical location. Tools used may include videoconferencing, chat systems, and realtime shared applications, such as collaborative writing or drawing (synchronous) and email, newsgroups and shared databases (asynchronous). While

CSCW may form an integral part of a knowledge support system, all knowledge support systems do not necessarily support cooperation.

Computer-based training (CBT) is an old discipline dating back to 1960s, when IBM trained users of its mainframe computers with Coursewriter (Hawkridge 1988). This history is reflected by the multitude of terms used over the years to define the variety of computer systems used to facilitate learning (*table 12*). These terms have reflected not only development of technology (from computer to multimedia to web) but also development of learning paradigms (from teaching and instruction to learning). The main difference with knowledge support is that that training takes place before actual task execution, and often not in task context.

Table 12. The multitude of terms and associated acronyms that have been associated with learning applications of information technology. Adapted from Kasvi (1991).

(Interactive) (Intelligent)	Computer Multimedia Hypermedia Internet Web WWW	Based Assisted Aided Mediated Managed Enhanced Interactive	(Self) (Collaborative)	Training Learning Instruction Education Teaching Development Study Studying Coaching Tutoring Testing

The infobase containing the knowledge content of a support system is often actually a knowledge management (KM) system or an enterprise data management system (EDM or EDMS) or it may contain a product data management (PDM) system (*figure 11*). The role of the knowledge support system may be to act as an interface to these higher level systems, identifying relevant information and presenting it in a format that is applicable in work task context.

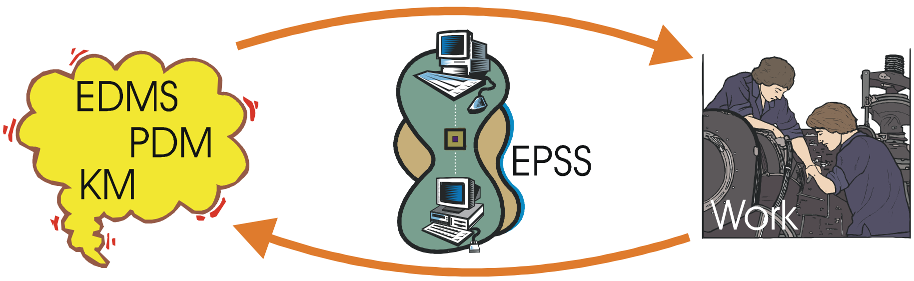

Figure 11. Knowledge support may act as a bridge between work task performance and higher level information systems.

2.5.5 Knowledge support cases

Good examples, especially studies of actual support systems and their influences are rare in literature[2]. What is more, the systems described are often addressed only from the technological point of view, and the organisational and social issues are neglected.

This subsection collects findings from 33 case studies conducted on different knowledge support systems. The list is a result of an extensive search through literature. This search would have been impossible without access to several web-based article databases provided by the library of the Helsinki University of Technology.

Several case studies found have been omitted from this list, as the papers discussed only requirements and design issues of a support system to be developed, or documented a system to be implemented. Or as O´Gorman (2001) notes in the summary of his case study of the SAS Maintenance Support System: "It would also be interesting to collect some real data on the performance of the SAS maintenance organisation before and after the system was introduced to try and quantify the benefit in some way". An American Society for Training and Development (ASTD) study on the use of electronic performance support systems in companies found out that only 31 percent of companies with at least one EPSS in use had evaluated the system for effectiveness, and only 10 percent of the systems had been evaluated for improved job performance and only five percent for return-on-investment (Benson 1997).

The *table 13* below is divided into four columns. The first describes shortly the system studied and its context, the second identifies the goal of the study, the third describes the data and methods used in the study, if available, and the last column presents the findings and outcomes of the study. In some of the cases, one or even two of these issues has not been addressed in detail. As a result, even some of the summaries in the table below, are somewhat terse.

While the table below summarises findings of tens of studies in a compact format, an even more compressed perusal was needed in order to find the common and the distinctive factors of these studies. This summary has been appended to this study as Enclosure 1: Key features of the case studies analysed.

Table 13. Knowledge support case studies identified from literature, their goals, data and methods, and findings and outcomes.

[2] There exists a good source of descriptions of commercial performance support systems and tools in the Internet. The EPSS Central presents several systems that have won the annual Performance Centered Design Competition awards in: http://www.pcd-innovations.com/infosite/design_awards.htm