Final Report

Work Package 2c

e-Learning environment

Contact authors: Arvid Staupe, Norwegian University of Science and Technology (Arvid.Staupe@idi.ntnu.no)

Vegard Hage, Norwegian University of Science and Technology (<u>Vegard.Hage@idi.ntnu.no</u>)

Contributions from: Högskolan i Kalmar Høgskolen Stord/Haugesund National Technical University of Athens Stiftelsen TISIP Universidad Politécnica de Valencia

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Author team of MENU reports

Contributions to MENU reports are produced by staff members at the partner institutions. All of these persons have taken part in discussions and production leading to this and other reports. Contact authors for this particular report are listed on the front page.

Partner #	Institution	Country	Staff members contributing
P0 Coordinator	Stord/Haugesund University College	NO	Harald Haugen, Svein Ove Lysne, Anders Grov Nilsen
P1	TISIP Research Foundation	NO	<u>Thorleif Hjeltnes</u> , Geir Maribu, Arne B. Mikalsen
P2	Agder University College	NO	Bodil Ask, Kjell Skaug, Åke Bjørke, Ola T Aas, Bjørg Aasheim,
P3	Norwegian Technical & Natural science University	NO	Arvid Staupe, Vegard Hage
P4	Technologiko Ekpedeftiko Idrima, Tessalonica	GR	Demostenes Stamatis, Theodoros Kargidis
Р5	National Technical University of Athens	GR	<u>Nikos Papaspyrou</u> , Manolis Skordalakis, Symeon Retalis, Andreas Papasalouros, Paris C. Avgeriou
P6	Universita' di Roma, "La Sapienza"	IT	Marco Temperini
P8	University of Greenwich	UK	<u>Miltiadis Petridis</u> , Gill F Windall, Elisabeth A. Bacon
Р9	Finnish Virtual University / University of Turku	FI	<u>Erno Lehtinen</u> , Eija Ristimäki, Eija Prossor, Kari Salkunen, Julian Lindberg, Taru Jokinen
P10	Kalmar University College	SE	Tom Gagner, Peter Diedrichs
P11	Universidad Politécnica de Valencia	ES	<u>Vicent Miquel Rodrigo Peñarrocha,</u> Miguel Ferrando Bataller

Other staff members may have been involved with activities related to the project, course development, dissemination, secretarial work etc, but are not directly involved with the content and authoring of these reports.

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e-Learning environment

An e-Learning environment is defined as a system for web-based learning which covers the total architecture for e-Learning, from the e-Learning system itself to administration and arrangement of courses.

Objectives

MENU has defined as goal to describe and demonstrate, wholly or partly, model(s) for e-Learning environment, where student-centered learning methods are in focus.

The learning environment shall further stimulate the students to influence the learning plan, and to enrich the possibilities for cooperation between students.

Keywords in this occasion are responsibility for own learning and communication.

Description and demands

Learning Management Systems are introduced and widely adopted instructional designers and by institutions, in order to fulfill certain needs and requirements in a field of ever increasing demands for pedagogically improved education and training and for better access despite distance both in time and topography.

The learning environment has to offer good opportunities for:

- Presentation and navigation of the learning material (Multimedia)
- Own development of knowledge as independent student product or as group work.
- Group-oriented learning processes
- Availability in time and space through different forms of communication (text, video etc.), data network, modem and so on.
- Adapting the learning system to different national languages
- Integration with the administrative Information Technology (IT)-systems of an institution

In addition, an important criterion is that it should follow standards as much as possible. This is to prevent unnecessary complications with unrecognizable files and to simplify the use of previous files etc.

Consequently the people involved in the decision-making process concerning instructional design and organization of educational institutions would use a Learning Technology Management System in order to:

- Create, operate and administrate on-line courses
- Support the collaboration between students and provide motivation and resources for team building

- Create and deliver questions and tests for student assessment
- Administer virtual, distributed classes where the students are geographically scattered and communicate via the Internet
- Organize educational, financial and human resources

These diverse usage scenarios of LMSs, correspond to different **categories**, which are respectively the following:

- **General systems**, which have a number of tools for creating and managing courses and do not give emphasis to any particular set of features. We call these systems "general" and not, for example "Course Management", because they provide a plethora of features that span many assorted areas, in order to provide fully functional on-line courses, such as communication tools, administration tools, etc.
- **Collaborative learning support systems**, which emphasize on team building, student group management and providing the synchronous and asynchronous collaboration tools to support the aforementioned activities.
- Question and test authoring and management systems, which facilitate a virtual workbook, where the student can perform course-related tasks, aside from following the course itself for example contact other students or course assistants, perform exercises etc. In addition, the system must facilitate design and construction of exercises and quizzes etc., which are published on the WWW and taken on-line. They provide tools for statistical analysis and reporting and automatic creation of assessment exercises.
- **Virtual classrooms**, which establish a virtual space for live interaction (with the use of text and video) between all the participants in the learning process, i.e. instructors, tutors and students.
- **People and Institute resources management systems**, which deal with human resources and financial management.

The LMSs that fit in one of the above categories support a number of **features**, or tools or capabilities in order to carry out certain tasks. These features do not discretely belong to only one LMS category but can be shared by several categories. These features can be classified into certain groups, namely:

- **Course Management**, which contains features for the creation, customization, administration and monitoring of courses.
- **Communication Tools**, which contains features for synchronous and asynchronous communication such as e-mail, chat, discussion fora, audio/video-conferencing, announcements and synchronous collaborative facilities (desktop, file and application sharing, whiteboard).
- **Student Tools**, which provide features to support students into managing and studying the learning resources, such as private & public annotations, highlights, bookmarks, off-line studying, log of personal history, search engines, virtual workbook etc.

- **Content Management**, which provide features for content authoring and delivery and file management.
- Assessment Tools, which provides features for managing on-line quizzes and tests, project deliverables, self-assessment exercises and so on.
- **Class Management**, which contains features for user management, team building, projects assignments etc.
- **School-Management**, which provide features for managing records, absences, grades, student registrations, financial administration etc.

For more information, see **References**.

Description of work

Work in work package

With four partners participative in the work package, we set up for a work plan where each partner selected an e-Learning system, either by oneself, or in cooperation with other partner(s), and then describe and develop a demo-model for it, with weight on the items described above.

We at NTNU, as the leader of this work package, sent out a questionnaire to the partners of the work group, to get an overview of what is used and the functionalities of these. In addition, we also asked for contributions to the final report. With such a questionnaire, we also hoped to get a look into the similarities and dissimilarities that exist between the different systems. Finally, we wanted to study to what capacity information between the different e-Learning systems could be exchanged, based on the standards the systems are built on (if any).

In **Table 1** we see the result of this questionnaire.

Criterias	UPV	HSH (1)	HSH (2)	TISIP	NTNU	NTUA	Hyperwave
Name of the product(s)/ system(s)	H.A.U.P.A.: Herramienta de Autor de la Universidad Politécnica Abierta	Class Fronter	IT's Learning IS Learning (same as HSH(1))		IT's Learning (same as HSH(2))	eClass which is a Greek translation/ adaptation of Claroline	Hyperwave eLearning Suite
Origin	Spain	Norway	Norway (see (see (eClass, but Claroline is HSH(1)) HSH(2)) an International product)		Greece (eClass, but Claroline is an International product)	Germany/Austria	
Open/closed software	Open	Closed (with possibility of choosing tools)	d (with possibility choosing tools) Closed (see (see HSH(1)) HSH(2)) Open		Open	Open (customizable)	
Platform (Windows, Macintosh, Unix etc.)	Windows	Windows and Macintosh	Primarily Windows, but also Macintosh	(see HSH(1))	(see HSH(2))	Windows and Linux	Windows, Unix, Sun Solaris, Linux
Use of network (Intranet, Internet etc.)	Intranet and Internet	Internet	Internet	(see HSH(1))	(see HSH(2))	Internet	Intranet, Extranet and Internet
Which specific e- Learning standards are used	None	ne IMS, SCORM, AICC IMS, SCORM, AICC (see (see HSH(1)) HSH(2)		(see HSH(2))	None (yet)	AICC	

Local for the Institution, National or International product	Local	International	International	(see HSH(1))	(see HSH(2))	(None)	International
Multilingual support	No	Yes	Yes	(see HSH(1))	(see HSH(2))	Yes (based on Claroline)	Yes
Cooperative functions/ tools (asynchron/synchron)	None	Both synchron (bulletin board,chat) and asynchron (discussions,shared documents,messaging,e- mail) Both synchron(chat,use online overview) an asynchron(messagir service, discussions		(see HSH(1))	(see HSH(2))	Asynchron (discussions, e-mail)	Synchron (chat) and Asynchron (messaging, discussions, infoboard). Includes Hyperwave eConferencing Suite – a virtual conferencing center
Possibility for building courses, publishing etc. (especially the pedagogical aspect)	Yes	No authoring tool integrated, but includes editor with integrated office-tools(Word, Excel etc). Option of adding files.	Tools for adding files/links, writing notes, co-editing, authoring tools, library-service (re- use). There also exists predefined course templates.	(see HSH(1))	(see HSH(2))	Do not provide any course templates, but does have quiz making tool	Wizard-based courseware creation, Media Depot (Content Re-use, CD Publisher)
Exercise functionality	Yes	Tools for portofolio	Tools for submitting exercises, questionnaire s and multiple choice-tests	(see HSH(1))	(see HSH(2))	Yes, for web testing, assignment upload and marking	Yes

ls searching available?	No	Yes	Yes	(see HSH(1))	(see HSH(2))	No	Yes
If searching is available, what kind of searching?	-	Full-text search	Keyword, metadatasearch and search for persons	(see HSH(1))	(see HSH(2))	-	Full-text (including thesauri, synonyms, etc.)
If searching is available, is it possible to narrow the search or specify areas?	-	No, the search will include all content in the course	the search will all content in the course the course		(see HSH(2))	-	Yes, into course content,discussion forum,course library etc.
Which file formats are supported? Are these possible to mix together?	All. Requires the client to have the specific software for a given file type in order to open.	All. Requires the client to have the specific software for a given file type in order to open.	All. Requires the client to have the specific software for a given file type in order to open.	(see HSH(1))	(see HSH(2))	All. Requires the client to have the specific software for a given file type in order to open.	More than 200 file formats are supported. Does not require specific software on the client side, other than a supported browser.

 Table 1: A questionnaire regarding the functionality of the different e-Learning Systems used at some of the ENU-partners' Institutions. Some partners use the same type of system, and instead of repeating the functionality of the system several times, we instead refer to the Institution in question.

A learning-theoretical platform and choosing a course for implementation

There are many important issues that must be faced in the process of choosing a course for implementation. We have placed emphasis on implementing a course that covers especially the pedagogical aspect. *How can a Learning Environment on the Internet be created, based on constructivism and socio-cultural approaches?*

The universities are being criticized for creating passive students and for teacher managed methods, based on old behaviouristic learning theories. When *Information- and Communication Technology* (ICT) now makes it's entry, there is a risk that teacher managed models will be copied into network-based learning.

In the last few years, *The Norwegian University of Technology and Science* (NTNU) has been working actively towards the development of a more flexible, problem- and projectbased learning, in which network-based learning creates the foundation. Constructivistic learning-theory and situated learning have formed the pedagogical background, particularly to be capable of offering flexible learning possibilities when it comes to lifelong learning and the need for continuing vocational training in trade and industry.

Constructivistic learning theory/situated learning

From a historical perspective, the design of the first computer-based training programs was based on behaviouristic learning theory, where learning is thought of as passive acquirement, or absorption, of an already existing and often rigidly defined amount of information. The main role of the teacher is to gather formal knowledge, to find efficient ways of distributing this knowledge, and to control that the students have acquired the taught material. Then cognitive learning theory followed, focusing on how the material is presented, and development of computer-based ways of teaching which emphasized the presentational form and intelligent guidance systems.

Even though we can't find the same enthusiasm within learning theory today when it comes to the effect of such managed and organized teaching, we witness the International education market explode with offers concerning manage-based teaching, especially when these are directed towards continuing vocational training. From our own schooldays we carry with us the knowledge that learning means to be quiet, to watch and listen, and then, finally, to be tested of what we remembered. Therefore, it doesn't seem too strange that this model is copied into network-based learning environments, especially not when the Internet as a medium is extremely suitable for fast and comprehensive management and distribution of information, and flexible both in terms of time and place. However, research on learning theory has in recent years been increasingly focusing on the fact that learning comes through active participation and collaboration in entire social-/cultural environments. Constructivism was rooted in the perspective that knowledge is acquired through personal construction of knowledge and arose in connection with *Piaget's* research on developmental psychology. Piaget introduced a theory on learning where new information act together with old knowledge through a process of assimilation and accommodation (Piaget, 1985). *Papert* (1980) further claims that the activity of programming computers could play an important role in constructivistic learning and related this to his work on the programming language, *Logo*. Here, the learner plays the role as "teacher" in relation to the computer.

In the 1970s, based on Piaget's theories, a group of psychologists, the so-called *Genevan School*, carried on research on how social interaction affects each individual's cognitive development. The main-thesis claims that each individual is capable of handling new knowledge by interacting with others. Individual cognition is seen as a spiral of causal connection.

The other theoretical main influence was the research carried on by Russian psychologists who were interested in the cultural basis for human intellect and researchers from the social-cultural perspective. The best known of these Russian researchers is *Vygotsky* (1978) who formulated the theory on cultural historical psychology. Vygotsky general genetic law of cultural development stipulates that learning always is a two-level process: first as an interpersonal act in a social community and then as an internal/personal process.

Internalization refers to the genetic link between the social and the internal plans. Social speech is used for interacting with other people; inner speech is used for talking to oneself, for reflection and thought. The social-cultural approach focuses on causal connection and connection between social interaction and individual cognitive change. Vygotsky's theory on "*The Zone of Proxymal Development*" (ZDP) has been interpretated in various directions. One interpretation claims that ZDP is the difference between a person's ability to solve a problem on his/her own, and what the same person is capable of when collaborating with others. Another interpretation of Vygotsky's ZDP is the distance between an individual's personal knowledge and the knowledge that exists in social situations. In both these interpretations learning happens through social interaction which inspires to individual acquisition and internalization of knowledge.

A related school represented by the Russian researcher *Leont'ev* (1974) et al., focuses on the role of active participation for human development, the so-called "*Activity theory*". The basis for analysis is social activity, from which individual mental functions are developed. This one focuses on signs, symbols, rules, methods, instruments and other artifacts which serve to mediate this activity. Vygoysky's cultural-historical psychology, and later on the work of the activity theorists have again developed successors both in relation to educational research and in the specialized arena of computer science directed towards human/machine interaction.

In theories on situated learning is seen as a process for entering a practical society.

"To learn to use tools as practitioners use them, a student, like an apprentice must enter that community and its culture. Thus in a significant way, learning is, we believe, a process of enculturation" (Brown, Collins, & Duguid, 1989).

Within this perspective, the learning context (both social and cultural) is under heavy investigation, from a view which states "that agent, activity, and the world mutually constitute each other" and that knowledge must be presented in an authentic context, in which this knowledge normally is integrated (Lave & Wenger, 1991). For these researchers the environment is a complete part of cognitive activity, and not just a set of relation through which context-dependent cognitive processes are expressed. Collaboration is seen as the process in which a common understanding of a problem is created and maintained. While the earlier approaches focused on the inter-individual levels, common-cognition and situated learning are now focusing on the social level where new concepts are being analyzed as a group-product.

From constructivistic-/situated learning theory we have decided to emphasize three main principles of learning and to look upon these in relation to design of internet-based learning environments:

- 1. Focus on active actors with intentions and creativity, searching for knowledge and collaborators.
- 2. Focus on collaboration and communication between the actors
- 3. Focus on learning in a total context/environment

Learning-theoretical platform

When it comes to the learning theoretical aspect we have been working from a hypothesis saying that the learner is the one who is active and hardworking. That is, it is not enough being passive during lectures and then make an all-out effort before the exam, or possibly now and then. Thus, it was for me very important to create a scheme where not only the naked facts are emphasized, which in turn are reproduced at the exam, but also that one should become productive and creative from working with the course material.

Today we say that we have an enlightened society where new information is very easily accessible and where it is expected that we keep our knowledge updated. It's not enough to only learn the naked facts but also to find our way faster and faster through a constantly changing knowledge environment. If not, our knowledge will become "reduced" in relation to the world around us. It is not the fact that we forget that creates this reduction but rather the amount of information. However, there are also professions that change at a similar paste.

The process of learning is therefore a part of a much bigger context than just learning the facts from a course material. The learning process is connected to both the facts that we're supposed to learn and to the context in which the knowledge is to be used. The way a teacher, the learning process, acts has become very significant. Having a practiced learning process makes it much easier to explore a changing knowledge environment at a later point, a process which creates the foundation of lifelong learning.

We are now living in a time of change where we're about to move from broadcasted education to interactive learning (Tapscot, 1998). Ordinary lectures are classified under broadcasting, not least when it comes to big lectures. This is not case with interactive media. *Eric Edvards Vogt* (Vogt, 1995) represents the different elements of a good learning process as a DNA-model. As we know, DNA is the high-molecular connections that create the genetic information which in turn controls the processes of all living organisms. The DNA-model reminds us that in reality all learning results from a combination and re-combination of different types of learning activities.

Coaching

Coaching can contain lections, coaching when choosing exercises, give hints, simplifying complexity, evaluating activities and diagnosing problems. However, it also includes training of the student's ability to observe and to ask questions. Learning how to ask questions is in many contexts just as important as solving exercises. By asking questions, wondering, one learns how to seek knowledge, and you become hungry for acquiring more.

Learning in Teams

Through this kind of activity one learns to establish confidence and to cooperate, how to ask motivating questions and how to participate in a creative process by using dialogues. In a good learning environment a person will acquire two kinds of knowledge. The first one implies acquiring the concrete knowledge demanded by the exercise. The second one implies functioning as a learning individual within the environment, having the ability to fit in with other people and taking joint responsibility. The knowledge of a well-functioning group is bigger than the total amount of knowledge from individuals (Edvin Hutchins, "Cognition in the wild", 1996). This is especially emphasized by the researchers of situated learning. *Resnick* (Resnick, 1994) stresses the fact that most their lives human beings *learn* and *work* together and not individually, as it often is at school.

Most people have experienced the joy of being a part of a well-functioning group – where the members trust each other, where they complement each others strong sides and compensate for the weak ones, having common goals which are bigger than the individual's goals, and where teamwork gives excellent results.

Desktop learning is the expression that Vogt uses for representing learning when using interactive media, hypermedia – multimedia. Using such media is supposed to support various teaching styles and engaging the students in being active in the learning process.

For example, it is possible to seek information by using completely different possibilities than what has been possible in traditional education. By using desktop learning it becomes possible to read, write, listen and talk.

It is possible to adjust the DNA-model to different types of learning. Central types of learning are *learning by discovery, problem-based learning* and *project-based learning*. All of these types of learning are closely related and fall under the heading *active learning*. *Learning by discovery* follows a learning process which is based upon abstraction, experimenting, observation and reflection. This forms part of a loop, a discovery loop. The tutor abstracts the material, gives exercises, etc. and the students follows up by using desktop learning. It is important that the students learn to articulate and presenting their reflections.

So, how is it possible to design internet-based learning environments on these main principles?

Structuring a virtual competence environment

Based on these learning theoretical principles, we have tried to find out how available services on the Internet can be structured and used in order to promote a learning environment with active actors genuinely collaborating in a total context. The resources/services that are available in a virtual competence network can be structured in relation to tasks and activities to be emphasized. We have chosen to structure the services into five arenas, according to which tasks/theories that are to be dealt with:

- A presentation-arena for presenting and receiving scientific literature/theories
- A *knowledge* arena for accessing library services/on-line services and other accumulated knowledge
- A *working* arena to manage collected material/information and produce new material
- A *private* arena to make personal notes and reflections
- A *communication* arena, which together with the working arena, make up the main core of a learning process based on constructivism and situated learning.



Figure 1 shows a graphical view of the electronic learning arenas on the Internet.

Figure 1: The electronic learning arenas on the Internet.

Presentation-/lecture arena

The criticism against behaviouristic learning theory is especially directed towards the belief that "someone can teach someone something" and that learning can be managed by the teacher. Thus, the possibility of spreading huge amounts of science material in a simple and flexible way by using network-based systems shouldn't be confused with learning. Science material can be presented and mixed together via network-based systems through different kinds of media, such as text, drawings, pictures, animation, video, and audio. It all depends on the one(s) having the knowledge how this knowledge can be made available to others.

The activities related to this arena are on one side to present information and on the other side to receive information. And vice versa if the communicating parts are equal. Based on cognitivistic principles, this arena will be important if the material is organized properly.

How great the activity related to this arena will be, depends on the amount of information to be mediated. For example, there will be relatively much more activity on this arena if the system is being used in relation to a defined material/course (reproducive learning), than in relation to creation, e.g. related to learning organizations.

Competence arena for accessing library services and other accumulated knowledge

This arena is also an information arena. However, its main emphasis is to actively search for information/answers for the topical questions. Thus, accessing databases

and libraries will be in the form of searching in relation to accumulated and stored information, while requests made to an oracle service may either be contact with resource persons and/or with accumulated information, e.g. stored answers in "Frequently Asked Questions" (FAQ). The services in both the presentation arena and the knowledge arena must first of all be seen as resources in relation to the actors learning process.

Working arena for organizing and producing science material

This is an arena for personal organizing of material. This is the real learning arena, if based on constructivistic learning theory. The learning takes place through the student's treatment of information and production of new material. The tools available in this arena are the same as those in the presentation/lecture arena, but now as tools for organizing and producing your own material. Group-ware tools are included also here in relation to personal work but communication with others is done in the communication arena. The workbook is also here when working with personal material but the storage of this one is in the private arena.

Private arena for personal notes and reflections

Basically, the private arena is supposed to be used for storing personal material. The private workbook is stored here.

Communication arena for interaction and collaboration

This arena is for communication and organizing in relation to other people. Together with the working arena, this is the most important learning arena if based on situated learning. Here, together with group-ware tools, e-mail and the *World Wide Web* (WWW) create the communicative foundation.

Tools and help services to realize Learning Environments in Internet

In order to realize this new network-based learning environment it has been necessary to develop a number of tools and help services in order to increase the smoothness of the layout and the production of network-based scientific literature, and support for the learning co-operation. These tools consist of an infrastructure tool based on the Internet and includes tools for hyper-/multimedia-systems, video on demand, animation, object-orientated design based on constructivistic learning principles, infosearch in free text, a knowledge test based on free text, an oracle-/help service, a workbook, and a plan for student administration. We have also developed specifications for necessary services in group-ware, but this is not realized yet.

The Infrastructure tool creates the complete frame for the learning arena and ties the arenas/functions together. Consequently, the arenas are able to communicate and use the resources across the borders.

The tool for creating *Hyper-/multimediasystem on Internet* make it possible to use media such as video, navigation, lecture-paths, personal paths, lectures on video synchronized with information in the hyper-system, and the possibility of making personal notes for each node, personal working arena, choosing language, fonts, colours, background, etc.

The Video on demand tool edits video (e.g. a lecture) and makes it possible to synchronize events in order to find the desired picture/sequence. By using this tool it also becomes possible to edit overheads and animations in relation to a video sequence. This is useful if one wants to use several media in order to strengthen a message. Video on demand is available from 28.8 KiloBits/Second and up to a few MegaBits/Second if needed. We have chosen to connect the main service for video to *Video On Demand* instead of *Multi Cast*. The reason for this is i.e. to be able to reuse already produced material without conflicting with the law of copyright. Multi Cast is to be considered as broadcasting and thus it doesn't allow for such an opportunity.

The Animation tool makes it possible to create animations which don't demand much band-with. It is also possible to control the animations step-by-step from a video-lecture. For example, this may be desirable if one wants to illustrate a process and explain what's going on simultaneously.

The Object-oriented design tool makes it possible for a teacher or a student to build a set of objects by using their own knowledge about a subject. Based on the objects one may easily construct systems in which the system and the work progress are visualized and animated during the execution.

With use of *the tool for Info-search in free text* one may search for information in free text; the information and the search are compared by use of vectors. Nonsense-answers can be rejected, whereas answers with a touch of reason can be guided. Here, the teacher can decide where to draw the line between nonsense and reason.

The Oracle service/help service tool structures and creates a connection with an online help service. Questions and answers are stored for later use in an automatic service for "Frequently Asked Questions".

The Digital workbook structure tool gives possibility to make sure that learning is done through one's own activity and production, activities in an electronic workbook are very important. The workbook is a frame into which the users are supposed to put their own product and not a book where you fill in the correct answers, or where you practice defined tasks. This workbook is also available to course administrators/tutors in the period of study, so that course-related discussions are connected to the work of the learner and which they show through the product that the workbook will become.

It is also possible to share and develop a workbook in collaboration with other students/partners. Connected to the workbook, there are tools for editing, asking for help and possibilities for tutor/colleges to add comments. It is possible to divide the

workbook into chapters. Which tasks that are connected to each chapter will depend on whether there is a special course to be completed or whether the workbook is being used as a public domain for documenting the work in progress. If the workbook is to be used in connection to specific course content, it is up to the course administrator and those participating how to proceed. One example of how to structure the workbook:

- Preface, where the participant presents himself/herself.
- A chapter where a group of persons, single or together, creates an overhead series in order to present a part of the material to each other. That is, the participants function as "teachers" for the rest of the group. They do this in turn so that everyone gets the opportunity to present course material to the others in the group.
- A chapter for writing a summary of lectures/presented material.
- A chapter for practicing exercises. These are solved through discussions and by working in groups.
- A chapter for a project assignment.
- A chapter for miscellaneous.

From a learning-theoretical perspective, based on active creative actors in genuine collaboration, we think that the working arena and the collaboration arena can create the foundation for such an active collaborative learning process, whereas the presentation arena and the knowledge arena can be considered more as resources for the actors work and production. A well-designed network-based learning environment can, as we see it, create the foundation for active, creative collaborative learning.

Network-based learning environments and learning organizations/social context

According to the principle that learning takes place, and is closely connected to social context/environment, the network-based environment may either be seen as the total learning environment, separated from the social reality where people belongs, or as an integrated part of a bigger social context. When collaborating with companies, municipal services, regions, we have tried to see virtual competence networks as integrated parts of an organizational context representation.

However, such an integration demands focusing on internal learning processes and organizational development at the collaborative parts. That is, at both the knowledge institution/university and the company/service. From our point of view, it is through the possibility of collaborating and communicating through network-based environments we enable the possibility of collaboration between environments that genuinely seek each other's competence without considering time and place. However, this requires good effort and a conscious mind. If not, the network-based environment will operate outside the institutions, both from the Universities and the companies, and will not be an integrated part of the context.

The selected course

We at NTNU have developed such a multimedia course – a course in Operating Systems. This system is developed as a system for research on the design and implementation of e-Learning systems and how they can be used in practical teaching, and is intended to demonstrate some of the possibilities of an e-Learning system.

This is a prototype developed at NTNU which has the same course content as the course which we have implemented in our solution Hyperwave eLS(described later). This system(hereafter referenced as *Opsys*) has been used and developed over a number of years at NTNU and has a number of tools that we wish to incorporate into our solution, Hyperwave eLS.

The learning environment

The learning environment consisted of a homepage with miscellaneous information and access to services, such as the hypermedia-system and the oracle service. Traditional lectures were often recorded on video and synchronized with topical material in the multimedia/hypermedia-system. This way, it became possible to listen to lectures and repeat at a suitable moment. Compared to the DNA-model, the lectures are part of the coaching part in the DNA-model and in the presentation-area in virtual learning environment. There was a workbook attached to the course, and here the students were supposed to present their own and their group's reflections of the lectured material.

A hypermedia-system (a multimedia system) on the Internet was created for the course, and also a workbook was made. Most of the written material in the hypermedia-system was duplicated and added to the workbook as a compendium. A part of the material existed only in the hypermedia-system, i.e. this was the case for animations which use the dynamics of the computer and therefore badly suited for duplication on paper and for the video-lectures.

Figure 2 shows a screenshot from the hypermedia part of the course Opsys.



Figure 2: Screen shot from the system Opsys. The menu-system is shown as buttons in the top frame, whereas the course content is in the lower frame.

We will in this section go into the depth of only three of the many functions of this system, because the purpose here is to merely give a look into the hypermedia structure of the system, and not the entire system.

For a complete list of the functionality, please refer to **Appendix 2: Overview of functionality in Opsys**.



Graphical view of the course content Also includes info on visited pages (history log).

Disorientation problem/Maps

The special structure introduced by hypermedia often causes difficulties to orienting oneself in the hypermedia-base. This confusion is often present in large systems, especially in systems with more than 500 nodes. The course Operating Systems is much larger than 500 nodes which leads to a twofold problem:

- How does the structure of the document look?
- How does one find the desired information?

A number of techniques are implemented in the hypermedia system, which is intended to reduce the level of disorientation, for example with the use of paths, video paths and so on.

In this reference, we especially would like to point out the metaphor *maps*, which can be used and presented as nodes by a hypermedia-system.

Figure 3 shows a screen shot from the function that shows the graphical view of the course content, entitled *The Eye*.



Figure 3: Screen shot from The Eye.

The following features are included in The Eye:

Feature	Description
Tilbake	Back
Hjem	Home
Fram	Forward
Lås	Lock: either locked or open. If <i>locked</i> (as in the
	Figure) one can navigate through the hypermedia- system with the use of the map, whereas if it's <i>open</i> one is restricted to navigate in the map only(without the hypermedia-system).
Lenker	Links: Choose between showing only primary
	links or all links.
Gjem	Hide: Exit the map.
1 uke/2 uker/	1 Week/2 Weeks/3 Weeks/1 Month/1 Year:
3 uker/ 1 mnd/	History map with colours that shows when the
2 mnd/ 1år	different nodes(pages) were last visited (by six different time periods). The students can choose colours themselves.



Video lectures directly connected to course content

Here we have the option of following video lectures which are connected to the walkthrough of the content within the hyper system. During the lecture, the content is presented simultaneously both on the video lecture and in the hypermedia system.

The students can at all times interrupt the lecture and navigate in the hypermedia system for depth study, make own notes and so on.

The video lectures are indexed so that the student also has the option of choosing which parts of a lecture he/she wants to look at. This makes it possible for a student to repeat and focus on selected parts of a lecture, if desired.



Make own paths/lessons/guided tours/personal paths in the course content

Instructional Systems

When Hypermedia is employed in interactive instructional systems, the student may move around at will in the content, hopefully learning while jumping from node to node.

Merely browsing the system alone can be very insufficient. Instructional systems require the ability to guide the students through the material, and thereby creating recommended paths to follow \rightarrow *guided tours*.

Guided tours

Guided tours are paths designed by the Author, leading from node to node. A reader wishing to go on a guided tour will then follow the nodes in a predetermined order. Conceptually, a guided tour is considered a linear organisation structure.

The guided tour mechanism may be used for instructuating new students. It may be employed to teach new students how information in hypermedia is structured, as well as to introduce students to a new hyperdocument.

Another application area is to use this as a presentation tool. A teacher may structure a number of nodes in the hyperbase to serve as a guided tour on a particular topic. The student will follow the teachers ordering of the information, never considering which nodes to select.

The teacher thus manages to place the focus on the information he wants to convey. In this respect, guided tours may also be considered as an orientation tool.

Personal paths

With personal paths, a student has the option of starting a sequence of nodes leading to information frequently accessed. By employing these, a student may follow an information path to where the student knows where he or she will find the desired information.

Students can both construct and edit personal paths. The student also has the option of at all times navigate in the hypermedia system for depth study, make own notes etc, both in guided tours and personal paths.

The *advantages* of this system can be listed in a few points:

- The system is developed at NTNU over a number of years as a system for research within the use of e-Learning, and it is therefore thoroughly tested and used in the course Operating Systems at NTNU
- The fact that the system is developed locally, has the advantage of knowing the complete structure and behaviour of the system, and therefore more easily adapt the system to our needs
- This system is also built to accommodate the content of the course Operating Systems, which has a non-sequential structure, hypermedia-structure/multimedia. This means that it is meant for the students to decide their own sequence of the course themselves, rather than to follow a predefined sequential structure. This is a structure not often found in other e-Learning systems.

But there are also some *disadvantages* of using this system:

- Whereas the system works very well once the content is implemented into the system, the process of editing content as well as adding content is somewhat time-consuming and troublesome as well. It requires a considerable amount of knowledge of the system in order to perform these tasks relatively effective, and is therefore not to prefer for everyone.
- The system also lacks some functionality in order to be a complete e-Learning system, especially on the collaborative part. Functions as discussion forums, chats and so on, are examples of functions that should be included.
- Because of the fact that this system is developed only as a system for research, the process of maintaining and updating the system is somewhat troublesome. Students that work with the system one period, eventually moves on to jobs or other schools, and new students will have to use much time and effort on learning the structure of the system in order to change or update the system later on. A system developed by a commercial third party would eliminate this problem by for example making updates available for downloading and installing.

All in all, there is a need for a complete solution for an e-Learning system that can solve the problems listed above. Several factors had an effect on the decision of choosing a system, but in particular two of these factors wore of vital importance:

- 1. The system must have the possibility of creating extensive hypermedia structure. We see the future online courses as comprehensive multimedia systems, thus with a structure more leading to hypermedia structure, rather that the traditional sequential structure.
- 2. The system had to have the functions described above as missing in Opsys, integrated in the system structure

Choosing demo-system

We have described solutions for what equipment the course supplier should have in order for the student to achieve an optimal functionality. Description of minimal-solutions has been carried out as well. For the choice of system to use as demo, we have focused on finding a system that covers the demands presented earlier, especially under **Description and demands**.

Our choice for such a system, that has integrated both an e-Learning- and Information System, is **Hyperwave eLearning Suite(eLS)**. This system is partly developed in close connection to other EU-projects, among others the project "An Experiment in Open and distance learning using New Technologies" (EONT)¹.



Our solution: Hyperwave Information Server

Figure 4: The architecture for Hyperwave IS/6. (http://www.hyperwave.com/e/downloads/images/is6_architecture.zip)

¹ <u>http://www.softlab.ntua.gr/research/research_projects/EONT/</u>

The framework for our solution to an e-Learning system is called *Hyperwave IS/6* (Hyperwave Information Server, version 6). The information system IS/6, is a complete and modern object-oriented information system with web interface. The system is available for several platforms, including WinNT 4.0, Windows 2000/XP, SUN Solaris 2.6, Linux 2.2.x, IBM AIX 4.3, HP-UX 10.20 and Compaq Tru64 4.0. (Hyperwave eKnowledge Infrastructure - Whitepaper)

Integration

Hyperwave IS/6 is designed to support integration with several systems. All underlying integration with other systems (for example via LDAP), are all attended to at this level, including:

- Security (SSL)
- External web references and integrations
- Different levels of data-access (roles)
- Support for several languages (extendable)
- Version handling
- Access to the system via own file system
- Integration with Microsoft Office
- Automatic control of consistence

eConferencing Suite

Hyperwave eConferencing Suite is a fully featured conferencing environment that is tightly integrated into Hyperwave's *eKnowledge Infrastructure*². Figure 5 shows an example of a typical video conference in eConferencing Suite.



Figure 5: Screen shot from eConferencing Suite. (http://www.hyperwave.com/e/downloads/images/ecs_screen.zip)

Included features with eConferencing Suite is Text-based Chat, Whiteboard, Audio- and Videoconferencing, Shared Presentation, Application- and Desktop-Sharing, Minutes Editor, Questionnaires, Ad-hoc and Scheduled Sessions, Collaborative and Managed Sessions, Save and re-play Sessions within Hyperwave and finally, Awareness functionality. (Hyperwave eConferencing Suite)

For more information on eConferencing Suite and its features, please visit the following address: <u>http://www.hyperwave.com/e/products/ecs.html</u>.

² A suite of modular knowledge management/e-Learning applications incorporating content and document management, search and retrieval, workflow, collaboration, audio/video conferencing and e-Learning.

eKnowledge Suite

Hyperwave eKnowledge Suite, a collaborative knowledge management solution, offers content and document management functionality for rapid deployment of corporate intraand extranets.



Figure 6: Overview of Hyperwave eKnowledge Suite. (http://www.hyperwave.com/e/downloads/images/eks_architecture_en.zip)

eKnowledge Suite includes many features that help increase productivity and collaborations, including Content Management, Document Management, Interaction and Communication and finally, comprehensive Security functionality. (Hyperwave eKnowledge Infrastructure – Whitepaper)

Read more at: http://www.hyperwave.com/e/products/eks.html.

eLearning system

The e-Learning system itself, builds on the basis system eLearning Suite (eLS), an application (a set of modules) that is a layer above the Hyperwave IS/6.



Figure 7: The architecture of eLS. (http://www.hyperwave.com/e/downloads/images/els_architecture.zip)

eLS (and IS/6) is organized for two of the largest suppliers of web browsers, Netcape (v.5 and later) and Microsoft Internet Explorer (v.4.01 and later).

Adapting of concrete templates opens for support for other web browsers than these two, for example Mozilla and the Norwegian browser Opera.

Tools for publishing (and editing) of data in Hyperwave IS/6 (and by implication in eLS), via Virtual Folders (this will appear as an ordinary disc in the file manager, that can be accessed and navigated) and/or WebDAV-support, are greatly emphasized. The Virtual Folders appear on the desktop as an ordinary disk drive in the file manager, which can be accessed and navigated as a local disk drive (for example 'C:').

In addition, the system supports publishing of information from the eLS onto a CD-ROM in a few easy steps.

Development of learning material (production)

Hyperwave offers many ways of producing learning material, these are: (Hyperwave eKnowledge Infrastructure – Whitepaper)

- Hyperwave Virtual Folders
- WYSIWYG HTML-editor
- Hyperwave Office Extension
- Hyperwave Publishing Wizard.

HyperWave supports Open Document Manager API (ODMA), which implies that ODMA-clients (i.e. Microsoft Word and -Powerpoint) can directly access information in Hyperwave, without having to go through a web browser.

eLearning Suite also offers so-called wizards for various tasks, a media-depot (recycling of already used contents) as well as test modules. Roughly speaking, eLS integrate with the most common development tools.

A particularly powerful function is the support for generation of Microsoft PowerPoint 2000-slides over to sequences of pictures that can be viewed in web browsers (integration for HLP Slide Library).

Statistics and reports

Each student has an overview over the following information: (Hyperwave eKnowledge Infrastructure – Whitepaper)

- The course(s) the student is attending
- The number of students in every course
- The percentage of the course which is completed by the student
- The degree of which this percentage diverges from the average student in the course
- Which parts of the course which is completed
- When the student visited the course for the first- and, till now, last time
- How long the course has elapsed

Standards

With Hyperwave as underlying structure, one has a very good basis for this type of use, which reflects the intention behind ADL SCORM:

- Exchanging information between systems
- Exporting/importing possibilities
- The learning material is built on the object structure of Hyperwave
- One can work with metadata from objects and upwards
- Links are objects as well, and can be modified to have one type of attributes as access rights etc.

File formats

In all over 200 file formats are supported, including the different file formats of Microsoft Office-files, different common multimedia formats, HTML, PDF and so on.

Each and every format that is identified, will be represented by its respected icon, and will also be searchable after full-text indexing by input. (Hyperwave eKnowledge Infrastructure – Whitepaper)

Implementation

Problems

The process of preparing and modifying our solution has been a process with many obstacles. First and foremost – the language-translation of the systems HIS and eLS wore *far more* complex and time-consuming than expected(and documented, for that matter). It should me mentioned that by far the most complications arised with eLS, and not the underlying HIS, which has been very stable, as expected. The language-files to be translated in eLS was not gathered together in a few directories(as described in the manual), but rather spread throughout the whole system, which is quite a few thousand files to go through. So it's safe to say this alone was a much more time-consuming task than one could expect.

This has to do with the often frustrating problem of that new versions are not always as compatible with old as one would hope. In this case, NTNU chose to use the new version of eLS(v1.3) together with HIS v5.5(as opposed to v6.0). This is partly because of our previous experience with HIS v5.5, which we feel has been very successful. In addition, HIS v.6.0 does not offer a built-in database, as opposed to v.5.5. This implies having to use extra resources with managing an external database (e.g. Oracle, SQL), which we feel would be unnecessary if we could 'avoid it' at this point (without losing functionality, of course).

Unfortunately, the combination of eLS v1.3 and HIS v5.5 is not supported by HyperWave, and therefore not well documented. This leads to problems with for example identifying where in the system code the different functions of eLS are placed, in order to easily be able to modify or add functionality.

Regardless of these issues, we use HIS v5.5 now, because of the advantages mentioned above, and because of that we think it is the best solution at this point.

One additional problem that we have experienced is the systems response time, which has been very variable. However, this may very well have to do with limitations on the hardware which the Hyperwave Information Server is running on in our lab. During the project period, we have run the server on a pretty "ordinary" machine³, and the results on a server with for example dual processor and more memory could just as well minimalize this problem we have experienced. This is of course just discrete assumptions from our side – the actual result would have to be tried out in order to know for sure.

Focus

Besides from preparing the course, we have focused on developing a solution for effective use of video and audio streaming in internet broadcasting. As mentioned, the use of video exists and have been used several years in the system presented Opsys, as well as at many, many other systems around the world. However, the use of video in video conferencing has up to now for the most part been focused on one-way video/audio streaming(with exceptions, of course). One of the reasons for this is the technical limitations on the Internet(delay in streaming), and thus making it less attractive. For two-way video/audio streaming in video conferencing to be attractive, the degree of delay (in seconds) between the participants is crucial. One of the main problems therefore lies in reducing this delay as much as possible down to an acceptable level, in addition to getting the conferences well organized.

Another main concern is the level of difficulty – the threshold to understand and make use of this solution. Without losing too much functionality, the design should be made simple and easy to understand, so that it will attract users instead of having just the opposite effect.

We initially planned on using this prototype in course at NTNU the Autumn 2003, but unfortunately, we decided not to make use of this, because of the time consuming problems which has made us unable of reaching the goals and demands we initially set for the learning environment. Thus, the course will also for this Autumn be running on the system Opsys, as described earlier.

³ Including Intel Pentium 4 2.0 GHz processor, 1 GB RAM

Results

In order to sum up what we've achieved, we go back to the requirements that we defined earlier, and put these into two groups, what we actually *have achieved*, and what we *haven't achieved*:

What we have achieved

Follow standards

Hyperwave eLS support the e-Learning standards defined by AICC. Additionally, because Hyperwave supports many different file formats, we can easily make use of known tools and programs, (such as Microsoft Office etc.) either separately or in combination. We are in this manner not dependent on any particular editor.

Own development of knowledge as independent student product or as group work

Hyperwave Virtual Folders (HVF) arranges for personal organization of material. Possibility of setting up a workbook. Typical tools are available for the students, but if needed – a group of people can be given common access to a work book for collaborational purposes. The students can also set up conferences as desired, both in reference to which people that can participate, but also which person is responsible.

Group-oriented learning processes

Hyperwave eLearning Suite supports an extensive use of teams. It is possible for both students and teachers to create teams based on registered users of the system. Members of a team can cooperate in many ways, including team-specific chats, discussions, messaging and by sharing files.

Availability in time and space through different forms of communication (text, video etc.), data network, modem and so on.

Hyperwave eLS supports several platforms, including different versions of Windows, Unix, Sun Solaris and Linux.

The e-Learning system also includes several ways of communication, including both synchron(chat) and asynchron(discussion forum, messaging, infoboard). Hyperwave also includes *eConferencing Suite* – a virtual conferencing center which includes such functionality as audio-/video conferencing, shared presentations, questionnaires, minutes editor and so on⁴.

It's possible to work off-line with a course, by downloading the course content and later on simply upload the progress so that the course assistant is informed about your progress in the respective course. In this way one doesn't have to stay online throughout the course in order to get any work done.

⁴ Read more at: <u>http://www.hyperwave.com/e/products/ecs.html</u>

Adapting the learning system to different national languages

There is a number of languages that the system can be translated to, but initially, the User Interface is fully available in only English(default) and German. The Information Server supports the following languages when using an integrated full-text search engine (including thesauri, synonyms, etc.):

• Danish, Dutch, English, French, German, Italian, Norwegian, Portuguese, Spanish and Swedish

Throughout the course, we have succeeded in translating the complete system into Norwegian (including both menu-structure and help-function).

What we haven't achieved

Presentation and navigation of the learning material (Multimedia)

As mentioned earlier on, we had some problems regarding the structure of Hyperwave, and adapting the hypermedia structure (as mentioned in Opsys) into the new system, eLS.

Figure 8 shows the overview of the course content we ended up with in this particular course described earlier (Operating Systems)



Figure 8: The course content of the course Operating Systems, in Hyperwave eLS.

As you may or may not see, the content of the chapters are being sorted by the titles of the pages – that is, the Norwegian titles. One can also sort by sequence number which is given to each page, if preferred.

When sorted alphabetically on title, the different topics within a for instance a chapter are mixed together, without any logical connection to each other, other than the title of the page. The result is therefore rather "messy", and not very preferable to use.

In the top frame of the screenshot from the system, you see some information about the page that is currently viewed, as well as options to print and update progress information. In addition to this, there initially was two navigation buttons (()) that we removed, in an attempt to solve the problem of navigation alphabetically. These buttons are originally intended to navigate between previous and next page in a course, with the underlying assumption that this is in fact the logical previous and next page, regarding the given topic. So by disabling these buttons and thereby removing the option of

navigating between pages that had no other connection other than the page title, we hoped to solve the problem of navigation.

But unfortunately, this had a side effect of disabling the progress feature of each student within a course. It seemed that the progress of a student within a course, are updated with the use of the navigation buttons, so by disabling these, we also disabled the progress function.

This is the most crucial problem we met, and which also in the end led to us *not* to make use of the course using Hyperwave eLS as planned at NTNU Autumn 2003.

Integration with the administrative Information Technology (IT)-systems of an institution

Because of the great amount of recourses used on dealing with the unforeseen problems in the implementation, we unfortunately didn't have enough time left on integrating the tools and functionality that we initially hoped for, into the new system.

However, Hyperwave eLS supports the *Lightweight Directory Access Protocol*(LDAP), which opens for integration of functionality into administrative systems at Institutions, so we expect this to be a relatively practicable process.

Graphical view, video lectures and paths

In the description of the prototype Opsys, we mentioned three functions that we feel are important, and we have not been able to integrate these in Hyperwave eLS. Hyperwave Information Server contains necessary qualities for this to be implemented, but it seems that this is not built into the version of eLS that we've had access to.

Conclusions

Based on constructivism and sosiocultural approaches, we have at NTNU tried to arrange for a network-based learning environment that supports active, creative students in a genuine collaboration within a total context. From our point of view, there is a great challenge in seeing the context as the foundation for integrating network-based learning; this applies not least to lifelong learning and continuing vocational training related to working place/environment. We have gained some experience in this interesting area by developing tools so that people with competence in one or several specialist areas could be able to express this knowledge in an Internet-based competence-network, and to collaborate with others.

We have made an attempt on implementing these ideas in a commercially available elearning system, developed in Europe. This is further described under "Implementation" and "Results".

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Appendix 1: LMS categories and features

Table 2 illustrates a mapping that portrays a typical relation between the aforementioned categories of LMSs. Analysis of the LMS features can be found in **Table 3**.

LMS Categories Supported Groups of Features	General Systems	Collaborative Learning Support Systems	Virtual Classrooms	Question and Test Authoring & Management Systems	People and Institute Resources Management Systems
Course Management	Х				Х
Class Management	Х	X	Х		X
Communication Tools	Х	X	Х		
student Tools	Х	X	Х	X	
Content Management	Х			X	X
Assessment Tools	Х			X	
School- Management	Х				Х

Table 2: Mapping between LMS categories and groups of features.

Features				
Content management				
Content upload				
Content authoring				
Content structuring				
Multimedia content insertion				
Other (than html) content types supported				
Tools for effective navigation inside content, guided tours				
Tools/wizard for content authoring				
Use of templates – reusability of content appearance				
Tools/wizards for content publishing				
Meta-data specification.				
Video lectures				
Student Tools				
Add Bookmarks				
Add Personal notes				
Get information about study progress				
Self-assessment quizzes				
Adaptive/personalized quiz presentation				
Search-in-content tools				
Self registration in courses				
Personal web page creation				
View his own grades				
Groups of students can share resources to facilitate team working				
Personal organisation of material (workbook)				
Workbook for group work				
Personal paths				

Communication tools
E-mail
Chat
Discussion forums
Video conference
Voice conference
Shared white board
Application Sharing
Sessions scheduling
File transfer utilities
Oracle-service/on-line help service
Assessment tools
Test content authoring tools/wizards
Test content upload
Automatic, scheduled test delivery.
Automatic test scoring
Automatic generation of resuLMS' statistical analysis reports.
Number of test types supported
Advanced security for increased examination procedure's reliability.
Automatic generation of quizzes from a pool
Adaptive and personalized quiz presentation
Course management
Syllabus Template
Calendar
Announcements
Glossary
Structure course access pages
Customizable-consistent course interface
Links to web resources
Class Management
Create assignments
Organize students in groups for team working on assignment projects
Assignments grading
Assignments grades statistical analysis
students' progress tracking
Administration
User Records Management
Course Backups
File management support
Database management support
Other Features
Online help

Table 3: Analysis of LMS features

Appendix 2: Overview of functionality in Opsys



Forward

Graphical view of the course content. Also includes info on visited pages(history log)

Search (an alphabetical list of keywords)

Make annotation

Video lectures directly connected to course content

Workspace (personal area)

Ć¢

Fle3: Tool for Computer Supported Collaborative Learning(CSCL), we use Fle3⁵ at the moment. Includes a personal web top, discussion forum, collaborative development and course & user management. Can easily be replaced by other collaborative tools, if desired.

Glossary: Computer and Internet definitions

Make own paths/lessons/guided tours/personal paths in the course content

Configuration of the courseware(layout, language etc)

Help page

Quit the courseware(close browser)

This indicate that you have made an annotaion for this document (click to open the annotation)

Add/save to workspace

Chapter

Document

Choose background (default is Paper background)

Choose knowledge level (default is *Level 1*)

Select language (for menu-structure & course content)

⁵ <u>http://fle3.uiah.fi</u>



Level 1 💌

Norwegian 💌

