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EXPERIENCES FROM DESIGN AND USE OF IT SUPPORTED DISTRIBUTED LEARNING ENVIRONMENT.

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ABSTRACT: The paper discusses design and use of distributed learning systems. Examples and experiences from ongoing courses are presented. Distributed learning is defined and put into the context of tomorrows learning environments and the project and problem based learning methodology used at Aalborg University. The requirements and properties of distributed learning systems are explained as well as available IT-tools support and requirements on underlying models. It is concluded that IT supported distributed learning provides us with excellent possibilities to advance the learning methodologies suitable for life long learning and to render existing courses more effective. At the same time we will design courses for new professions or professions with new content. This is a challenge in itself as it emphasis cross-disciplinary and free education content. There is a great need to raise the IT competence of the teachers to meet the needs for and carrying through of the changes in education on all levels. We will in the future see a closer natural collaboration between universities in course development and experience exchange.

KEYWORDS: Distributed learning, problem based learning, multimedia interface, authoring tools, world wide web, education, modeling, collaborative work

1. INTRODUCTION

Computer tools were introduced in the education during mid 1960s. At that time we used paper tape input and got 10 character per second print output on the Teletype. During the late 1960s main frame computers were introduced as well as punch card I/O devices. Computers were used in research and Master Thesis works. Around 1970 mini computers (e.g. Hewlett Packard, Digital Equipment) were installed at the university departments. In 1971 we were roughly 5 mini computer owners at Lund University. Our first computer, 1971, at the department of Structural Engineering was a HP 2114A with 8 kwords (12 bits) of main (core) memory and 0.5 Mhz processor speed. The cost in today's price was 30.000 US dollars. The price performance relation at that time was thus 30.000/0.5=60.000 and is today 1000/400=2 i.e. a factor 30.000 (30 years with doubling in 18 months gives 2**15 = 32768 according to Moore's law).

Today students (young and old) can begin to choose the best courses at different Universities. We will see an increased course specialization at different Universities besides the common basic course supply.

Our experiences are based on course and education systems development as well as teaching from around 1970.

- 1972 course in "Computer Controlled Measurements and data manipulation and presentation",
- 1983 courses in "Cad, and 3D- and database modeling using Medusa", (Christiansson and Herrera 1985). Workstations were expensive (25.000 US$),
- 1986 post graduate course in "Knowledge Based System",
- 1992 "New tools for knowledge transfer - development of hypermedia systems", (Christiansson et.al. 1992),
- 1995 "To use and evaluate MultiMedia". " and "Make your own MultiMedia Application"
- 1995 The Electronic Book exhibition at the Culture Museum in Lund (the first museum web installation in Sweden still in use on a SUN computer),
- 1995 design and implementation of virtual exhibitions at the Lund University Historical Museum (opened 1997), (Christiansson 1997a),
- 1996 design and development of Lund University Virtual Interactive learning Tool, LUVIT.
- 1998 courses at Aalborg University (IT tools in the Building Process, Digital presentation in Project Work, etc.) (http://it.civil.auc.dk/it/education/

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2. THE DISTRIBUTED LEARNING CONCEPT

2.1 What's new?

The learning process has not changed to any considerable degree during the latest centuries. A big shift came when the art of printing was introduced during the middle 1400 (Guthenberg) and it become practical and less expensive to pack and distribute information to a large audience. We are now further developing the 'art of communication', (Christiansson 1995), introducing dynamic logical packaging of information, rich underlying knowledge representations, shared workspaces and multimedial interfaces to information.

The most important changes due to introduction of IT in the learning process are (or will be),

- higher emphasis on *learning* (and learning to learn) than teaching,
- the teacher becomes more of a *tutor* (coach, facilitator) than an information disseminator,
- higher possibilities for *distant learning* (not in a physical but in a virtual class room),
- *life long learning* perspective becomes an important issue (time independent learning),
- new types of *interactive learning material* with more realistic and user adapted interfaces,
- greater possibilities to combine courses from different universities (*virtual universities*),
- possibilities to adapt and/or develop *new pedagogical methods* with respect to learning material, learning modes (exploration, discovery, problem based learning etc.), student competence and intelligence profile, collaboration, teacher roles, and social contexts,
- higher demands on *client competence* in connection with specification of distributed learning system and tools.

and

- IT in itself does *not* improve pedagogy and learning methods,
- high accessibility to vast information and a great variety of IT-tools puts higher demands on teachers to model learning contexts and users expectations and abilities – *situated action* (Suchman 1987),
- IT-tools and knowledge representations used must be (at least implicitly) *described* to the learner.

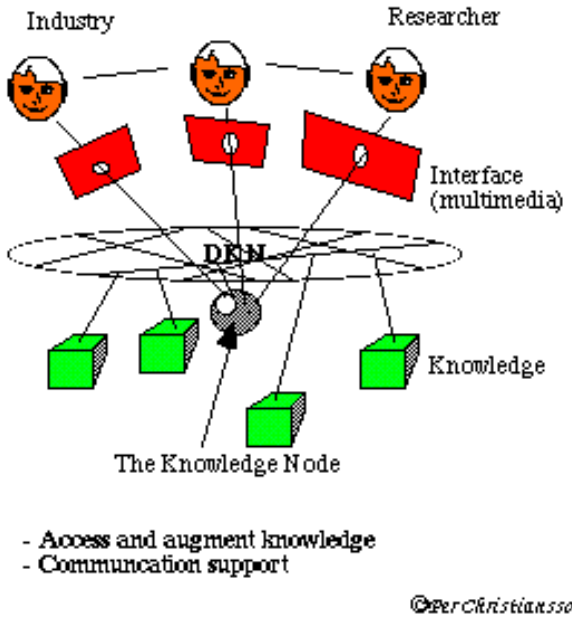


Figure 1 A knowledge node acts as support to (1) input and find information on the global networks (2) person(s) to person(s) communication and/or common working space. DKN is the Dynamic Knowledge Net which first implementation is the World Wide Web

A Knowledge Node, (Christiansson 1996), is a place you can visit and access knowledge or meta knowledge valid for a certain domain, see figure 1. The node also supports communication between persons and facilitates access to common work spaces. Information will to a great extent be presented in logical containers that are filled according to user needs according to meta level prescriptions.

Examples on *information content* is interactive movies, design and carry through of experiments, best practice and expert reports, product information, electronic libraries, student project works, course information and updates.

Examples on *communication* and social interaction is discussion forums, voice and text chat, video communication, common whiteboards, simultaneous access to shared computer applications, student feed-back, remote student-teacher interaction. See also (Woolley 1999) for a listing of collaboration tools and (Hills 1997). (In 1973 David Woolley created PLATO Notes, one of the world's first conferencing systems and the direct progenitor of Lotus Notes, DEC Notes, and many others).

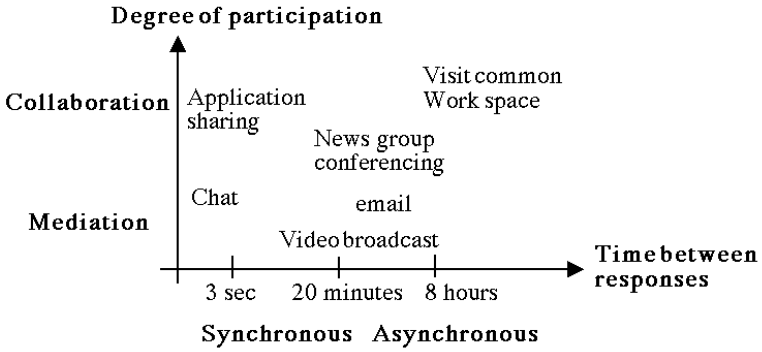


Figure 2 Communication between persons can take place in more or less real time and cognitive engagement in the 'virtual class room'.

Figure 3 tabulates major changes required to reach a richer learning environment during the transition from programmed instruction to situated learning.

Skinner/Taylor		L^3D
there is a "scientific", best way to learn and to work (programmed instruction, computer-assisted instruction, production lines, waterfall models)	--->	**real problems are ill-defined and wicked; design is argumentative, characterized by a symmetry of ignorance among stakeholders**
separation of thinking, doing, and learning	--->	**integration of thinking, doing, and learning**
task domains can be completely understood	--->	**understanding is partial; coverage is impossible**
objective ways to decompose problems into standardizable actiona	--->	**subjective, situated personal interests; need for iterative explorations**
all relevant knowledge can be explicitly articulated	--->	**much knowledge is tacit and relies on tacit skills**
teacher/manager as oracle	--->	**teacher/manager as facilitator or coach**
operational environment: mass markets, simple products and processes, slow change, certainty	--->	**customer orientation, complex products and processes, rapid and substantial change, uncertainty and conflicts**

Figure 3 There are strong similarities between the behaviorist learning theory of B.F. Skinner and the models of industrial work of F.W. Taylor, which contrast to the lifelong approach to learning, (Fisher 1996)

2.2 Virtual Class room example

Figure 4 shows a distant learning situation where a group at Aalborg University participates in a 2 hours lecture and exercise on image editing, see http://it.civil.auc.dk/it/education/secretary_teacher_1/lecture_5.html. Two physical rooms, one at Aalborg Univeristy in Denmark and one at Lund University in Sweden, were connected by two communication channels forming a virtual class room, see figure 5. A 3 line ISDN connection for video and an Internet TCP/IP connection to handle a shared work space were used. The Timbuktu software from Farallon Communication Inc, http://www.farallon.com/ (http://www.timbuktupro.com/) was used to handle the application sharing.

Figure 4 Left screen displays the common workspace, in this case using Adobe Photoshop, controlled from Aalborg and Lund Universities at the same time. The teacher is on the middle screen and the audience, as he sees it, is on the right screen.

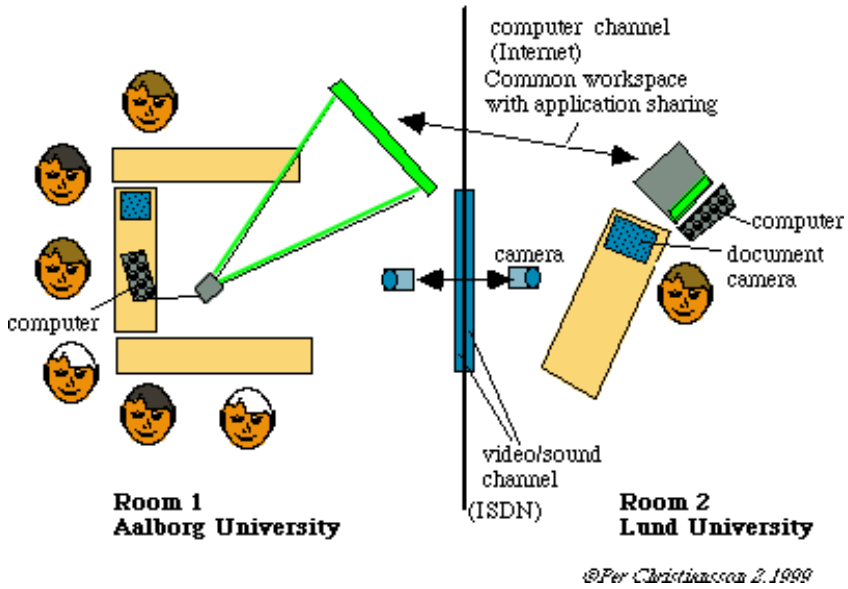


Figure 5 Example on a physical set-up of a virtual classroom. See also figure 4.

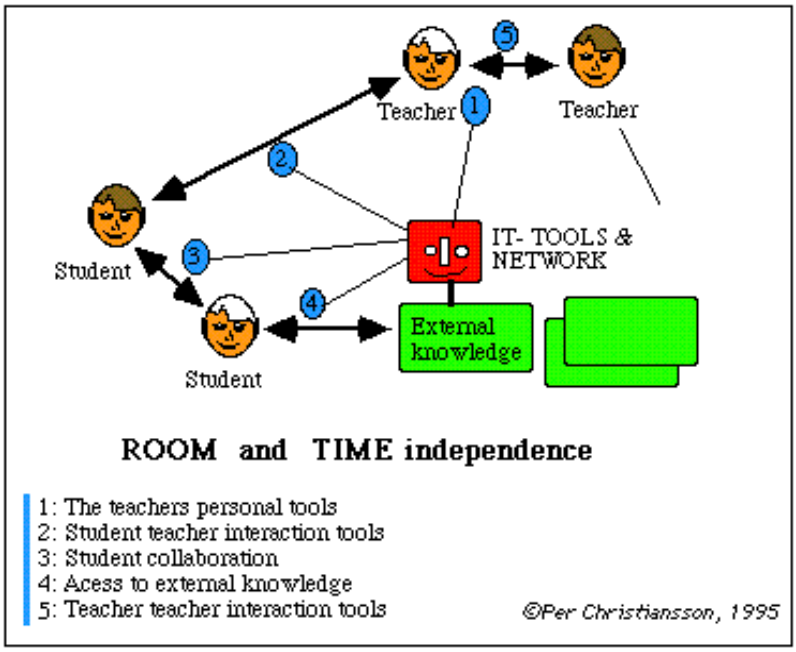
Some experiences concerning collaborative work from this and earlier activities at KBS-Media Lab (http://delphi.kstr.lth.se) at Lund University are,

- video/sound connection over *Internet*, e.g. over a CuSeeMe reflector (Modin 1995), is only adequate using very low image update,
- very good *social connection* may be achieved with the teacher/coach who though wished to have better eye and body language contact with the students (video cameras can be controlled remotely and should be preset at different positions),
- *shared applications* work very well both for collaborative production work and creative sketching.

2.3 What is Distributed Learning?

Let us make a *definition*

> "Distributed learning takes place in a virtual learning space that expands the conventional study chamber and classroom in time and room with regard to learning style and interaction modes as well as learning material and learning methods".



Figur 6 IT tools (new and existing) will support collaboration and information access in the distributed learning environments.

Introduction of Multimedia interfaces and networked learning environments will support communication between persons *irrespective of* if they are situated in the same physical room or not.

Figure 6 provides a map for how IT can support communication in a distributed learning environment. IT-tools will support personal communication and provide communication support with educational artifacts. It should be possible to

- create personal, group, and course *rooms/spaces* (physical and virtual) as well as social meeting places.
- create *working areas* for the mentioned spaces,
- ensure *communication* bandwidth capacity and network functionality (QoS, *Quality of Services*) for chosen information contents and communication requirements,
- provide mechanisms for personal, methodological, course, and system *developments* (easy feed-back mechanisms, help functions as wizards/agents, self tests, transparent system structure, client computer platform independence, expandable and flexible system, history recording of document and software changes, versioning, etc.),
- provide course, group and personal *administration* functions (e.g. planning, calendar, external database connections).

It is an ongoing process to design and develop new solutions for learning methods and supportive IT-tools. IT support in the learning process will be progressively integrated. Requirements are obtained from students, teachers, learning knowledge domains, learning contexts, and enabling IT. Continuos evaluation of learning process should take place to get feed back for changes in,

- pedagogic models
- learning material content and underlying digital knowledge representations
- physical learning environments
- teacher roles and competencies
- missing or inadequate resources
- student collaboration group work optimization
- teacher knowledge transfer and collaboration.

It was mentioned above that one important change due to introduction of IT in the learning process would be greater possibilities to combine courses from different universities (*virtual universities*). This involves development of agreements between universities on accreditation models, course credit models, as well as university evaluation and self-assessment systems. We will most probably see more courses and education programs developed and given in collaboration between two or several universities on European and global levels as well as more use at high-schools of material produced at universities

This paper will not go deeper into the complex domain of national and international education quality assurance models. See also (Grosjean 1997) and the Higher Engineering Education for Europe, H3E, site at http://www.hut.fi/Misc/H3E/.

2.4 The Aalborg experiment

The PPBL, Project and Problem Based Learning, methodology was introduced 1974 at Aalborg University. From (Kjersdam and Enemark 1994): "The curriculum in engineering as well as in the natural science is project-organized from the day the freshmen arrive until their graduation. The first year the freshmen learn to work in project-groups. The next two years in the undergraduate programmes the project work is mainly design-oriented. The last two years in the graduate programmes the project work is mainly problem-oriented (Problem Based Learning). ..... The duration of each project is one semester. In the programme half of the time is distributed to the project work, 25% to courses related to the project and 25% to courses related to the curriculum."

The system is resource demanding in office-space, supervision, constantly changed or renewed lecture contents due to high adaptability to University external and internal demands. But it is also an effective model. 80% of the students pass their examination at the prescribed time.

The 'IT in the Building Process' course mentioned later falls on semester 6, i.e. during the second half of the 3rd year with emphasis on project work.

IT-supported open MSc education has been run since 1991 at Aalborg University. The project/problem based learning pedagogic method is reported to strongly support new ideas on life long learning, (Bygholm and Dirckinck-Holmfeld 1997). The same authors also report that it is very favorable to start the education with a (partly guided) pilot project for the students to get acquainted with new ways of working and collaboration, project group forming, using new IT-tools etc. It is also important that a pedagogical dramaturgy is defined to support positive experiences and engagements to avoid student emotional blocking. Dramaturgy is closely linked to *user models* supporting user action, roles, emotions, cognitive processes and language.

PPBL will also provide the fundaments for a beneficial development of creative and critical student thinking techniques as well cooperative and collaborative learning with WWW support, see (Bonk & Reynolds 1997). The prerequisites are there for the open minded creative collection and exchange of ideas within groups and with tutors, collaborative problem solving, reflection, evaluation, and efficient visualization of the processes.

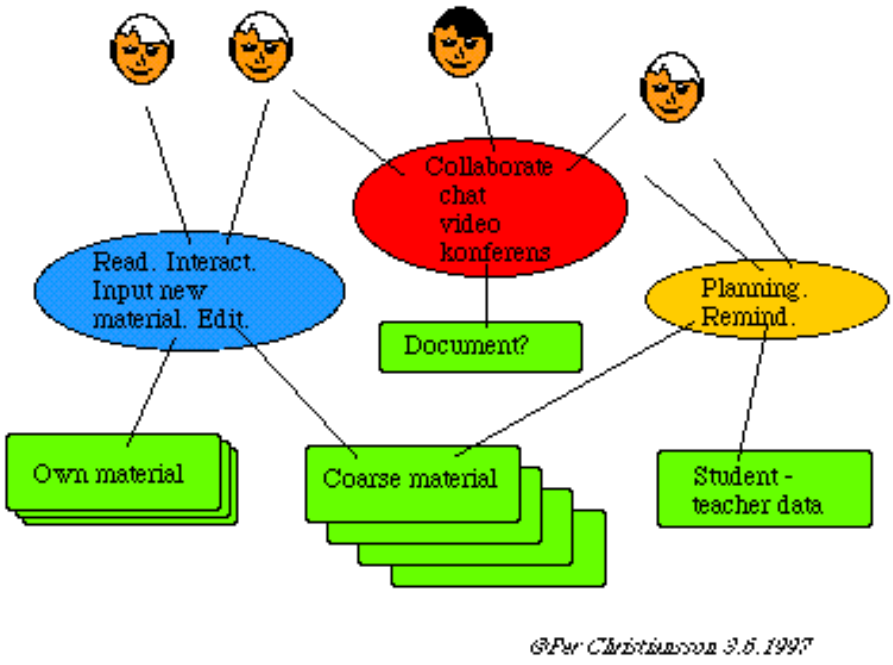
The 'IT Innovation at Aalborg University' project concentrates on the university application of information and communication technology in teaching, research and administration and is intended to make visible and utilize the experiences already gained by the departments of the university and its students, see http://www.iti.auc.dk/English/. Separate collaboration agreements have been established e.g. with Lund University in Sweden, see http://it.civil.auc.dk/it/projects/aau_lu/index.html.

3. DISTRIBUTED LEARNING SYSTEMS

3.1 Basic functionality

A distributed learning environment must support a number of functions. As we set-up such an environment we can either try to find a complete system which fulfills our needs or ourselves build a system from existing components.

In 1996 Lund University evaluated some of the existing systems available which could be used in a distributed learning environment; WebCT (http://homebrew.cs.ubc.ca/webct/), TopClass (http://www.wbtsystems.com/), Lotus Notes (http://www.lotus.com/), Web Course in a Box (http://wally2.rit.edu/fred/studentbasics.html), and the long used FirstClass, (http://www.softarc.com/). We did not want to work with a dead end turnkey system. The system should allow teachers to feed the system with course material without any knowledge about HTML and should have good administrative support functions. The result was that Lund University decided to develop its own system together with a software developer (after procurement), (Christiansson 1997b). The name of the system is now LUVIT, see also http://www.luvit.com/.



Figur 7 Main basic services in the distributed learning environment.

Below some experiences from educational IT-support systems development and use are recorded;

- *client competence* to support requirements formulation is often low (both on IT and methodological issues),
- actively *involve end users* in the requirements phase from the start of the project and onwards. Though be aware that non-linear thinking required for hypermedia design as well as knowledge on the influences of new IT-tools on learning methods usually are under developed (use learning by doing and best practice dissemination),
- follow up *costs* is often underestimated (e.g. new skills needed, change of working methods and organization structures, server maintenance, long term course material and student documents storage),
- strive for client computer *platform independence* (Mac, PC and Unix). Today possible through use of WWW and Java Virtual Machines,
- it may be necessary to differentiate between video (ISDN) and shared workspace (TCP/IP) *physical communication channels* . TCP/IP best handles only sound and still images today,
- be aware of the very different requirements posed by learning *context*, pedagogical *methods* and knowledge *content*,
- create *four user levels* for the learning environment - students, teachers, course administrator, system,
- *course material* typically supports self study and tests, lectures, individual and group exercises, project work, and social contacts,
- *teacher HTML knowledge* is required for optimal course development performance (high level WYSIWYG HTML editors are not good enough),
- *student HTML knowledge* is required to make project webs (not enough with copy-paste from good examples on the WWW),
- system *administration domains* are typically - student personal, student group, teacher, teacher group, department, university internal and university external,
- be open for using English instead of your national *language*,
- create good user *feed-back* facilities,
- system *availability* must be100%.

3.2 Multimedia and user models

Advanced multimedia interfaces, see figure 8, have made it possible, at least in theory, to adapt underlying course material to the needs and learning styles of the individual students and student teams. The underlying knowledge representations are not independent of the presentation and interaction models that in their turn accommodate the models of the users. Systems of today are eligible to house many user models. User models are seldom described in learning systems of today though the user interfaces implicitly contains such models. See also (Lagerstedt et.al. 1996).

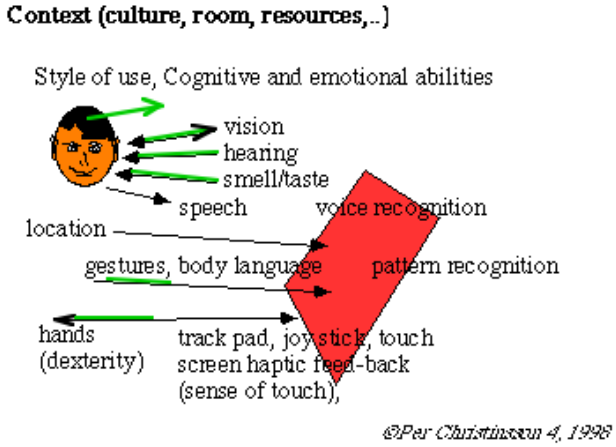


Figure 8 Multimedia interfaces provides us with possibilities to adapt to different user interaction styles, and cognitive and emotional abilities with high degree of realism.

3.3 Authoring tools

Course material can be produced in many ways. During the last 10 years the number of IT-supported authoring tools have grown dramatically and the teacher and students now have access to tools which are suited for different learning contexts and knowledge domains, see figure 9.

The course material reflects the *knowledge domain*, the *users* of the material, and the *context* in which it is to be used. Traditionally most material is produced in word processors and has a static form. Today we can mix different representations and make them interactively accessible through *multimedia* interfaces with high degree of realism. We can even let the learning system on the fly produce adapted material according to user and learning context.

The course material is accessed through multimedia interfaces. The delivery mechanisms are typically the Word Wide Web or CD (or both in combination). It will normally take one minute to download a 3 Mbytes interactive Director application called from a www-browser. So called *streaming technique* is very useful to control interactive access to large linear material (video or sound tracks) on a server without downloading the whole information chunk (film) to the client computer.

It is very useful to create *scenarios* or synopsis (visiting a shop, using a map, looking in a photo album etc.) that works as rooms for the 'story' the author wants to tell. Here the course aims and underlying materials meet. The narrative work, 'the representation in art of an event or story' see (Merriam 1993), can be supported by defining *themes*, ' a subject or topic of discourse or of artistic representation', (Merriam 1993), for example crossing a border, a birth, a journey, an exploration etc. (Christiansson et.al. 1992).

Different authoring tools support different scenarios and themes. Authoring tools based on filmmaking, flow diagram or hypertext metaphors have existed for practical use for over 10 years.

Some of the authoring tools that we have experiences from are mentioned below (runs on both PC and Mac). The WWW itself can also be used to house the whole material (HTML pages with additional scripts and Java applets).

- Authorware (flow diagram type) and Director (time line/film metaphor) from Macromedia Inc. (http://www.macromedia.com/index.html). (Director applications can be 'burned' and stored on a server for downloading to clients. This requires a http browser plug-in).
- Hyperstudio (Hypertext type) from Robert Wagner Inc. (now Knowledge Adventure) (http://www.hyperstudio.com). The pioneering program in this field was HyperCard from Apple Computer around 1988,

- ToolBook (hypertext type only on windows) from Asymetrix Learning Systems Inc. (http://www.asymetrix.com),
- FileMaker (Hypertext with database) from Filemaker Inc. (former Claris) (http://www.filemaker.com).

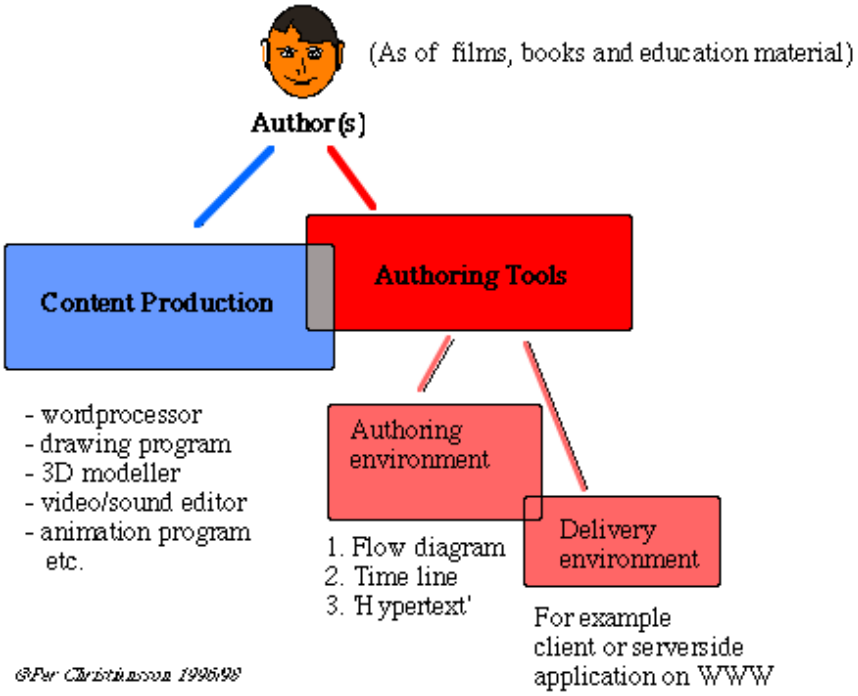


Figure 9 Authoring tools help teachers and students to produce and deliver digital interactive learning material.

A number of different domain knowledge experts, except from the domain under consideration, have to be present or available during the course development. Experts on,

- conceptual modeling of course material (writing of synopsis and storyboards, documentation of conceptual models, use of mind maps and flow charts),
- design of underlying data models and control structures,
- pedagogical models (e.g. project and problem based learning, story telling, simulation, physical experiments),
- human computer interaction, HCI, navigation and search metaphors, cognitive overhead (lost in hyperspace),
- cognitive psychology,
- human communication,
- system integration and networking,
- graphic design and image editing,
- scenario design and dramaturgy,
- animation,
- video production and editing,
- midi, musical instrument digital interface, and (multi channel) sound editing,
- desk-top publishing (layout, reading rhythm, fonts, etc.)
- evaluation models,
- requirements formulation,
- incremental prototyping and demonstrator development.

4. THE SEMESTER 6 EXAMPLE

The aims of semester 6 1998 course 'IT in the Building Process' are to

- give an overview and understanding of how IT has been and are used in the building process,
- give an overview and understanding of how IT will change the building process,
- mediate knowledge on how IT can be used to support the student project work.

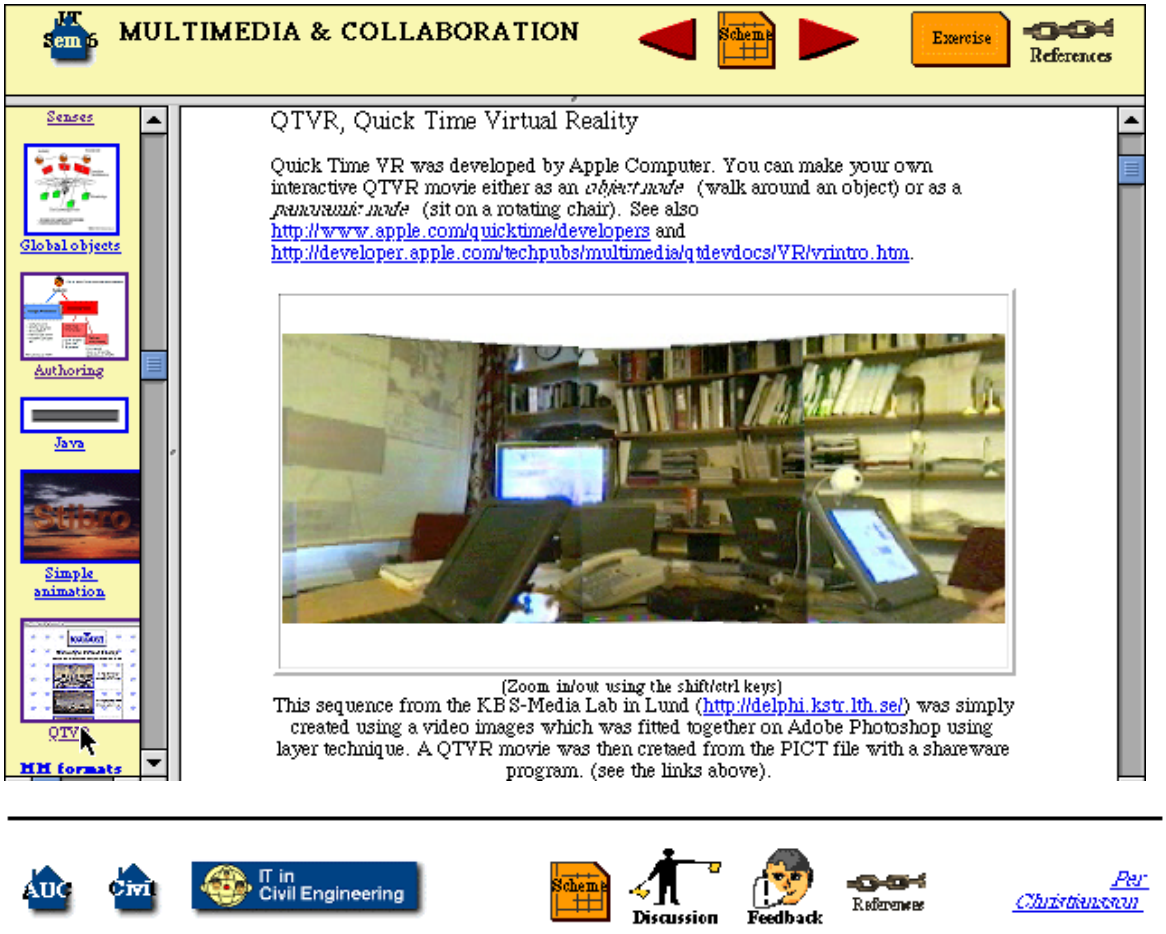


Figure 10 Aalborg University course 'IT in the Building Process' lecture notes are accessible from Word Wide Web.

The course covers in particular - IT in the building process, IT history, building product/process models, relational database design, decision support systems, building maintenance with IT-support, multimedia, collaboration tools, intranets, and IT-strategies, see (Semester6, 1998).

The students can use optional tools covering communication support and information handling for their project work. The course is especially dedicated to be support for the semester project work. The projects are carried out in groups on 4-6 persons and in most cases reported on the web, see for example http://it_civil_auc/it/education/sem6_1998/participants.html.

The *course material* in the form of lecture notes, exercises and references are available on the Internet from a WWW browser, see figure 10. The notes are easily scanned using a combined graphic/textual palette on the left side of the screen. Each of the ten lectures can be reached either via the 'scheme' icon or by stepping forward or backward in time (red arrows in figure 10).

The *exercises* cover project web design and implementation, relational databases design, multimedia support and collaboration tools. Lectures and exercises only takes place during the first half of the semester together with project work and courses in building statics, management, materials, structural engineering, production and foundation.

The *projects* are chosen from ongoing or planned authentic construction work in the area (e.g. office/dwelling housing, bridges, and tunnels).

Each student project team has a *group room* at its disposal where the students can connect their private computers to a hub with possibilities to establish an *intranet*. The project data can at any time be downloaded to a group area on a central http-server.

There is a common (for students and teachers) *discussion area*. We have implemented the Perl-script based shareware WWWBoard written by Matt Wright which can be found at http://worldwidemart.com/scripts/wwwboard.shtml. Students can at any time easily give course feedback.

We have also with good results tried a WWW-based evaluation system developed at Lund University (EVA 1998). Email is used extensively for communication as well as postings to all course participants.

The course is running now (spring 1999) for the second time. Some findings are reported below,

- students and teachers are not all *familiar* with the possibilities IT -supported collaboration provides (e.g. groups continuously documentating project progress, teachers using the student project web to follow progress),
- *guided exercises* are important for student learning by doing in small steps
- teachers must be highly *accessible* tutors and problem solvers especially during project kick-off and to make injections when group activities fade (search the problems). This poses special problem in a highly physically distributed environment,
- some groups want to have *intranets* only available for the group (they see a risk for improper result spread before the project is ready),
- the internet provides good opportunities for active search for knowledge *and background information* to generate ideas during the early project phases,
- *discussion forums* will not be used unless actively triggered by tutors.

5. CONCLUSIONS

IT supported distributed learning provides us with excellent possibilities to advance the learning methodologies suitable for life long learning and to render existing courses more effective. At the same time we will design courses for new professions or professions with new content. This is a challenge in itself as it emphasis cross-disciplinary and free education content. There is a great need to raise the IT competence of the teachers to meet the needs for and carrying through of the changes in education on all levels. We will in the future see a closer natural collaboration between universities in course development and experience exchange.

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