ICT SUPPORTED LEARNING PROSPECTS

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EDITOR: Per Christiansson

Per Christiansson, Professor
Aalborg University
email: pc@bt.aau.dk, http://it.bt.aau.dk

SUMMARY: *ICT supported learning has come more and more in focus during the last two decades. The wide spread introduction during 1993 of the World Wide Web (WWW) was a catalyst for deepened interest and extended implementation of learning and knowledge transfer systems. It is a well-documented (unfortunately) truth that the development within didactics has been very gentle during the latest centuries. Lately the development has taken a quantum leap due to standardization and global spread of the Internet based applications and communication support. We are in fact right now in the middle of an intense development phase where creative ideas on ICT tools and tools to design tools (meta tools) as well as new organization of the learning environment and enhanced pedagogical methods are tried out.*
This summer (2004) the ITcon Journal publishes a special issue on ICT supported learning. The special issue focuses on both practical and theoretical aspects of learning and knowledge transfer with special emphasis on experiences and future developments within the area. The issue reports experiences mostly from the AEC domain, but with findings and research results that are valid outside this area.
This editorial paper elaborates on properties of virtual learning spaces and ICT tools to support teaching, learning, and (meta) information handling taking into account improvement of learning styles, course content and learning material. Experiences from many years involvement in ICT supported learning and development of ICT in construction courses are reported with particular emphasis on the Aalborg University Project Oriented Problem Based, PPBL, learning model. Finally the six papers of the special ITcon edition on distributed learning are summarized.

KEYWORDS*: distributed learning, virtual learning space, IT in construction, leaning styles, collaboration, course content*

1. INTRODUCTION

ICT supported learning has come more and more in focus during the last 2 decades. The wide spread introduction during 1993 of the World Wide Web (WWW) was a catalyst for deepened interest and extended implementation of learning and knowledge transfer systems.

It is a well-documented (unfortunately) truth that the development within didactics has been very gentle during the latest centuries. Will we be facing a dramatic shift in development speed now that ICT tools are introduced on a large scale? Anyhow, the foundation is now laid. We can expect progress and change of the didactic tools, the way we learn and collaborate, the role of the teacher, learning material, and learning spaces.

We may distinguish some of the main driving forces for improved learning environments derived from introduction of new Information and Communication Technology (ICT) tools, which are under intense development.

- New *routines* and *means* for enhanced communication, collaboration and knowledge transfer.
- Separation of *information storage* and *access* media implying storage of all information produced, changed filtering and quality assurance mechanism and dynamically adapted information access.
- *Ubiquitous* and *wearable* computing i.e. seamless and everywhere accessibility to computer resources.
- Creation and use of virtual worlds and mixed/augmented reality *user environments* with multimodal Human Computer Interaction (HCI).
- *Globalisation* with cultural diversity and global market place development with greater possibilities to combine education and courses from different universities (*virtual* universities). See also the European Bologna Declaration (Bologna, 1999).

- Increased *modularisation* of information containers with dynamic formation of higher level containers and inclusion of time marked data. The semantic web, (Berners-Lee et al., 2001) provides a first generation tools to relate disperse web based information containers.
- Learning material *adapted* to personal competence, learning styles and access modes.
- More or less *'intelligent' artefacts* (agents) to support learning, self assessment and communication.
- Increased possibilities for *lifelong learning* independent of time and physical space constraints.
- possibilities to adapt and/or develop *new pedagogical and learning methods* with respect to learning material, learning modes.

This summer (2004) the ITcon Journal publishes a special issue on ICT supported learning. The special issue focuses on both practical and theoretical aspects of learning and knowledge transfer with special emphasis on experiences and future developments within the area.

In the call for papers it was stated that contributions should report practical experiences and methodological/theoretical approaches and have a multifaceted focus on issues such as:

- Distributed physical and virtual learning spaces;
- introduction of virtual 'worlds' and digital artefacts in learning;
- improvement of learning environments and learning domains;
- improved learning styles and learning/teaching methods
- properties and functionality of digital learning material;
- improved and adapted pedagogic, tutoring and teacher-student interaction;
- expanding target learning groups;
- improved assessment and evaluation methodologies;
- distributed project collaboration methodology;
- collaboration between universities;
- examination processes in virtual environments;
- curriculum development;
- producing and handling digital learning material;
- access to learning material;
- teacher support and collaboration;
- individual/group learning and assessment tools;
- feed-back and evaluation tools;
- maintenance of networked learning material containers;
- administration tools in learning systems;
- ICT frameworks.

This special issue reports experiences mostly from the AEC domain, but with findings and research results that are valid outside this area.

ICT supported learning has come into focus during the later decades originating from progress in engineering analyses and simulation software, information handling systems, advanced human computer interaction designs. Lately the development has taken a quantum leap due to standardisation and global spread of the Internet based applications and communication support. We are in fact right now in the middle of an intense development phase where creative ideas on ICT tools and tools to design tools (meta tools) as well as new organisation of the learning environment and enhanced pedagogical methods are tried out. This special ITcon issue gives evidences on progress in the field of ICT supported learning and will hopefully serve as an inspiration and support for successful continued development and evolution of the learning domain and didactic processes.

2. THE DISTRIBUTED VIEW

2.1 The virtual learning and workspace

We are now in the fortunate situation to be able to formulate needs and requirements as input for design of better learning (user) environments where student and teacher expectations could be better satisfied and stimulated. In fact we are in a phase of creative design of ICT supported user environments where existing environments can be enhanced and new ideas implemented, tried out and evaluated.

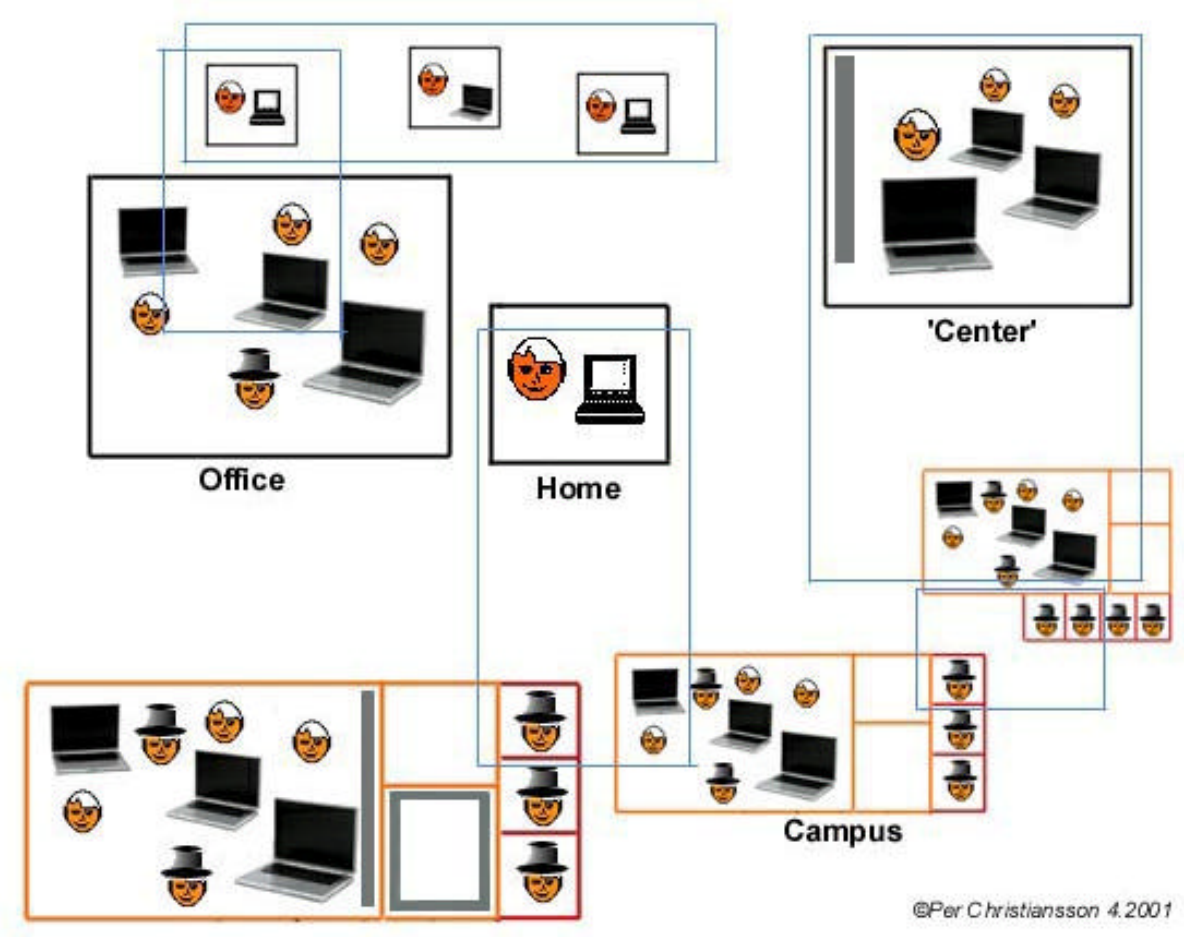


FIG. 1: Distributed learning takes place in a virtual learning space that expands the conventional study chamber and classroom in time and room with regard to learning style and interaction modes as well as learning material and learning methods From (Christiansson, 2000)

Three central issues in connection with properties for and relations between physical and virtual rooms are

- Distributed environments are in most cases complement to campus spaces;
- Rooms/spaces with new properties can be implemented (augmented, mixed reality and immersive environments, ICT tools transparency)
- Virtual rooms can change state (function and form) quickly (group room, personal, presentation, discussion,..) through opening and closing of communication channels, change of interface properties, access to adapted information resources, creation of social and emotional contexts.

The virtual learning spaces support synchronous and asynchronous communication between 2 or more persons independently of physical location. The virtual group room may not be as supportive of socially oriented activities as the physical room e.g. in connection with brainstorming, and complex activity planning, and capture of gestures and facial expressions, etc.).

From (Billinghurst & Kato, 1999) "Current CSCW interfaces often introduce seams and discontinuities into the collaborative workspace". They mention *Functional Seams*: Discontinuities between different functional workspaces, forcing the user to change modes of operation, and *Cognitive Seams*: Discontinuities between existing and new work practices, forcing the user to learn new ways of working.

Fully tele-immersive collaboration environments exist in the research laboratories, but are still too expensive and require further development to be used in practice. In these work spaces complete 3D models of the participants and the physical spaces are built-up and are accessible in the 3D space (i.e. we can also can see behind remote persons and objects). See also (NTII, 2000), (Altaf, 2003).

3. ICT TOOLS TO SUPPORT LEARNING

Information and Communication Technology (ICT) may be *defined* as the technology to handle information from capture, storage, manipulation, transfer to delivery through different media on all functional levels. Models of input/output artefacts and humans are mainly explicitly or implicitly stored in the capture-delivery parts of the chain and applications models in the storage, manipulation, transfer parts. See also the centre piece of figure 6.

During the latest decades ICT has matured, spread and been standardised to a high level of affordability and adapted learning support. Research findings and creative endeavours constantly improve the basis for development of improved learning environments. We here mention, see also (Christiansson et al., 2002), (Christiansson, 2001a), and (Christiansson, 2001b)

- Human Computer Interaction (HCI) with multimodal access to dynamically composed information containers and applications
- Communication and collaboration support (human-human, human-artefact, artefact-artefact)
- Digital information containers with modularised content and separation between storage and access media

ICT should give us possibilities to create *efficient, effective* and *user-friendly* easy to learn tools to support learning.

FIG. 2: The Panorama studio provides wide screen (if necessary in stereo mode) interactive access to computer applications for 25 persons. The right image shows 3D analyses of complex heated airflow in a ventilated room.

Virtual and physical learning spaces may be given properties to support different learning activities. Multimodal interfaces support the personal workplace as well as spaces for greater audiences and gives a more realistic access to computer stored models or digitally augmented physical realities, sometimes called mixed reality. Figure 2 shows examples from using education of the Panorama and CAVE at the VR Media Lab at Aalborg University. Low cost augmented reality solutions are developed at the research labs. See e.g. the Augmented Round Table for Architecture and Urban Planning project, Arthur, where virtual objects can be projected into the collaboration working environment by use of semi-transparent 3D stereo glasses and object and head tracking mechanisms. See also (Granum et.al., 2003).

FIG. 3: The 6 sided CAVE at the VR Media Lab at Aalborg University provides total visual and audio surrounding for small groups to experience and manipulate virtual worlds.

Virtual spaces for collaboration provide support for communication and shared access to applications. Figure 4 shows a low cost setup used in remote lecture and exercise sessions where two parallel communication channels are used. The personal communication is supported by fixed broadband ISDN connections, and the application is shared over the Internet with access control based on mouse movements. The set-up works well with the lecturer using externally controlled camera presets to focus in on the students. The personal contacts between lecturer and students are less intimate though compared to their presence in the same physical room.

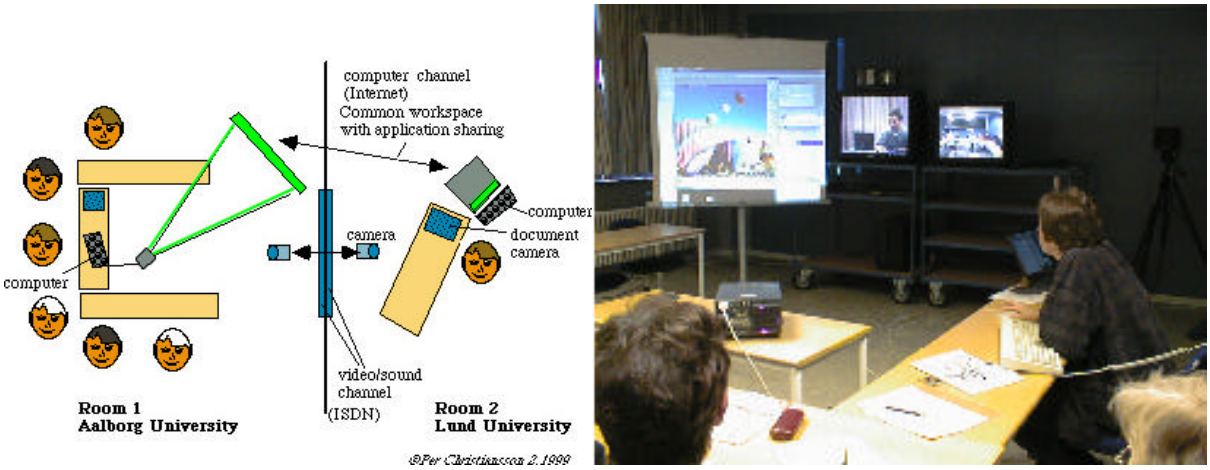


FIG. 4: Remote lecture and application sharing between Aalborg and Lund Universities 1999 during a teacher/secretary course, using parallel ISDN based video communication and Internet based application sharing. The big screen shows the shared application situated to the right of the lecturer in both his virtual and physical space.

Asynchronous collaboration may be supported by message boards or guided tours in (annotated) application models. Virtual Private Networks (VPN) can provide secure set-up of communication between several Internet domains. Peer-to-peer solutions where each computer in the network acts as both server and client become more widespread. Systems like Groove, http://www.groove.net/, support both synchronous and asynchronous communication in protected networks.

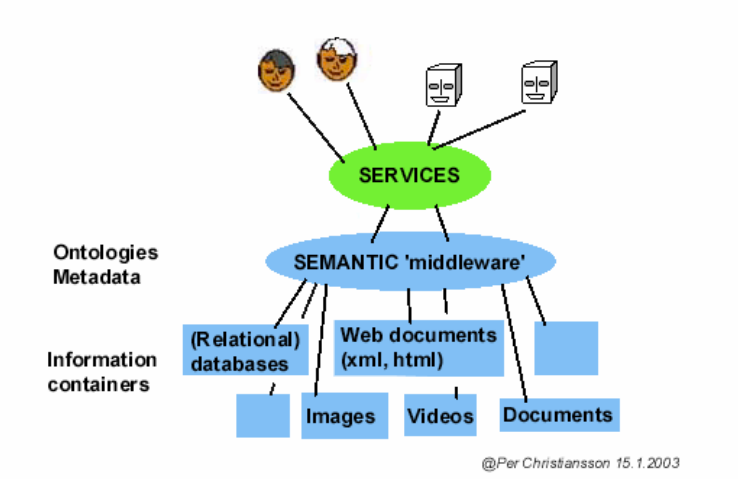


FIG. 5: New services for efficient handling of content in web distributed information containers will be introduced in the Semantic Web. From (Christiansson, 2003)

HTML (hypertext markup language) based documents have been stored on the World Wide Web since the early 1990s. Now the web documents may be separated into a content and presentation part through use of the XML (Extended Markup Language) and XSL (Extended Style Sheet) languages. Increasing number of resources on the Internet, labelled by their Uniform Resource Identifier (URI), can be described and reached through a common syntax and structure such as RDF, Resource Description Framework, see also (Christiansson, 1998). The web content is given meaning through introduction of standardized name spaces and schemas such as XML Schema (specifying structure and data types) and RDF Schema that gives meaning to the web based information containers. Efficient tools for improvement and development of new services are now tried out in the research communities. These services are based on ontologies that will provide a shared understanding of knowledge domains that can thus be communicated across persons and applications in what is called the semantic web (Berners-Lee et al., 2001).

Metadata are developed to support building information containers to support course design and course material management. The IEEE 1484.12.1 standard for Learning Object Metadata (LOM, 2004) (the full name of the standard is 'Standard for Information Technology -- Education and Training Systems --Learning Objects and Metadata') states "This standard will specify the syntax and semantics of Learning Object Metadata, defined as the attributes required to fully/adequately describe a Learning Object. Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of technology supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning." See also 'The Instructional Use of Learning Objects" online version at http://www.reusability.org/read/.

From (Learnet, 2004) Sharable Learning Resource in Hong Kong, "The LOM differs from library catalogue systems in that it incorporates data relevant to curriculum design and teaching methodology in addition to descriptions of content and authorship. However, efforts are being made to reconcile LOM with library systems as well as with learning management systems, such as WebCT, Blackboard, IVLE, etc. In the future, LOM will also include intellectual property protection and digital rights management." Links to Learning Objects Repositories can also be found at (Learnet, 2004).

THE EU project CUBER uses the IEE LOM standard, (CUBER, 2004) "The aim of the project CUBER is to build an adaptive high-precision information system for information technology (IT) courses of European universities. Special emphasis is placed on distance learning courses and other methods of 'just-in-time and just-in-place learning'.....The system will facilitate the access to the vast collection of courses offered by European higher education providers - in particular distance teaching universities, and make it easier to compare and exchange courses. In this way it can establish the groundwork for a Federated European Virtual University."

A Learning Management System (LMS) is, according to http://whatis.techtarget.com defined as a software application or Web-based technology used to plan, implement, and access a specific learning process. Different platforms support different learning environments more or less well with regard to learning material, type of communication/collaboration, learning styles, and learning theories. Typical functionality supported in platforms are

- Course curriculum description
- Course material publication and handling (teacher, student)
- (Weekend) seminar programs
- Project collaboration support
- Calendar/Progress review
- Document (file) sharing and versioning
- Multimedia communication support (asynchronous and synchronous, multimodal - text, sound, video, whiteboard, file transfer)
- Discussion forums, with subject marked and threaded discussions
- (Self) assessment, testing, and evaluation tools
- Personal information containers and student portfolios
- Student project results containers
- Application sharing
- Course administration tools
- Help desk and tutoring

Available systems today do not optimally handle all the above functions. The first web based LMS were introduced around 1996, after the introduction in 1993 of WWW clients. Among the first systems were Virtual-U <http://www.vlei.com/> 1996, WebCT <http://www.webct.com/> 1997, and Luvit <http://www.luvit.com> 1998. Today over 50 tested course management systems are presented at EduTools <http://www.edutools.info/>

Collaboration tools have a longer history. As early as 1968 the first trials were conducted. "On December 9, 1968, Douglas C. Engelbart and the group of 17 researchers working with him in the Augmentation Research Center at Stanford Research Institute in Menlo Park, CA, presented a 90-minute live public demonstration of the online system, NLS, they had been working on since 1962…….This was the public debut of the computer mouse. But the mouse was only one of many innovations demonstrated that day, including hypertext, object addressing and dynamic file linking, as well as shared-screen collaboration involving two persons at different sites communicating over a network with audio and video interface." (from http://sloan.stanford.edu/MouseSite/1968Demo.html).

Email traffic spread around 1985 (there were 2386 email servers at that time compared to millions now). Around 1990 the *CuSeeMe* software from Cornell University, Itacha USA was available and remote video and text chat communication over the Internet between many participants could be established. The central server was a so-called reflector for multi-casting 1990. The cilent platform on Mac computers was equipped with special video frame-grabber cards. White Pine Software 1993 released a whiteboard extension to CuSeeMe. 1990 my KBS-MediaLab at Lund University started to use application sharing (through remote screen control, WYSIWIS (What You See Is What I See) and file transfer by means of the *Timbuktu* program from Farallon, *Aspects* (Aspects, 1990) from Group Technologies for joint editing of drawings, word processor documents and bitmaps, and *First Class* from Softarc <http://www.softarc.com/> (a socalled BBS/Billboard system for structured email discussions). The programs used the AppleTalk network and later (around 1993) the Internet. The Basic Support for Cooperative Work - BSCW, http://bscw.gmd.de/about.html) were available 1998 and today we find a range of server and peer-to-peer based groupware.

For almost 10 years it has been possible to install free NEWS group type server software for structured discussions and document handling (e.g. Basic Support for Cooperative Work - BSCW, http://bscw.gmd.de/about.html) and today we find a range of server and peer-to-peer based groupware. In 1997 the peer-to-peer beta software Groove, created by the Lotus Notes pioneer Ray Ozzie, was released, <http://www.groove.net>. We have also used these two systems as project webs for distributed document handling and collaboration support in international project. The Groove system like Yahoo Messenger <http://messenger.yahoo.com/>, MSN Messanger (former Netmeeting) <http://www.microsoft.com/messanger>,

ICQ <http://web.icq.com/>, and iChat AV <http://www.apple.com/ichat/> support direct communication between two or more persons in more or less multimodal form (text chat, video transfer, and sound).

Below, some general experiences from our use of 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. But be aware that non-linear thinking required for hypermedia design as well as knowledge on the influences of new IT-tools on learning methods are usually under-developed (use learning by doing and best practice dissemination),
- Follow up costs are often underestimated (e.g. new skills needed as well as need for 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,
- Be aware of the very different requirements posed by learning context, pedagogical methods, personal learning styles, and knowledge content,
- Create four user levels for the learning environment - students, teachers, course administrator, system administrators,
- Course material should typically support self study and tests, lectures, individual and group exercises, project work, and social contacts,
- Teacher HTML/XML and web based system properties knowledge are required for optimal course development performance (high level WYSIWYG HTML editors are not good enough).
- Student deep 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 be near 100%.

4. LEARNING MATERIAL

4.1 Learning domains

ICT is a cross-disciplinary domain with strong relations to a number of established sciences such as computer science, cognitive psychology, mathematics, artificial intelligence, social sciences, and informatics. The Construction ICT is by nature also tightly connected to theoretical and practical building sciences. Parts of the learning domains are well supported by learning material e.g. literature on relational database and relational algebra based representations. On the other hand, many areas are still under formalisation, and learning material and courses must be dynamically composed leading to continuous update and development of courses.

Figure 6 shows building informatics related knowledge domains.

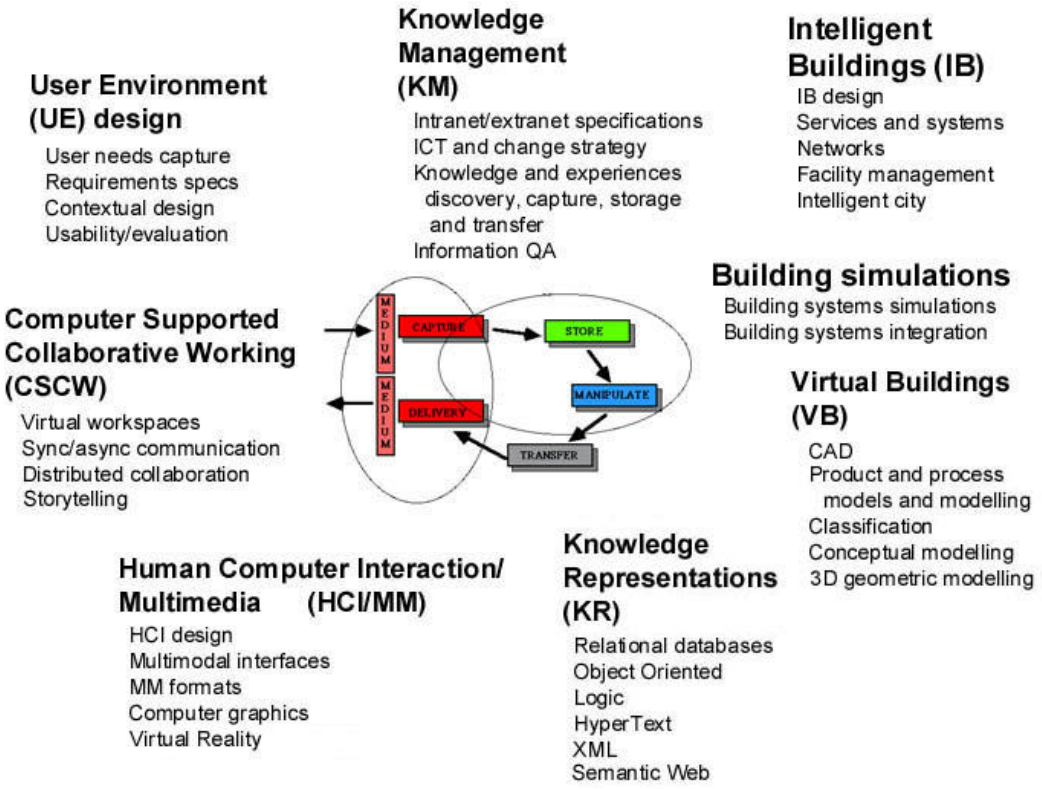


FIG. 6: Building informatics related learning domains. The Civil engineering and Master of IT and Building Management educations at Aalborg University covers several of the areas. From http://it.bt.aau.dk/it/education/overview.html

4.2 Course contents

According to Merriam-Webster - "Course: an ordered process or succession: as **a :** a number of lectures or other matter dealing with a subject; *also* **:** a series of such courses constituting a curriculum <a premed *course*>". A course involves student(s), teachers and tools to support learning, tutoring, collaboration, course administration, and (self) assessment. It is now possible to design courses in new innovative ways using ICT tools to better support student and teacher profiles and competences.

Teachers have to learn and master new ways to design and develop course content formats. Important parameters to take into account are:

- to combine courses from different universities (virtual universities).
- Higher emphasis on learning (and learning to learn) than teaching. The teacher becomes more of a tutor (coach, facilitator) than information disseminator.
- Provide, if necessary, ICT tools for distant learning (not in a physical class room, but in a virtual learning space).
- Life long learning perspective becomes an important issue (time and physical space independent learning).
- Utilisation of new types of interactive learning material and (self) assessment routines with more realistic and user adapted interfaces.
- Increased possibilities Possibilities to adapt and/or develop new pedagogical methods and learning styles with respect to learning material content, learning modes (exploration, discovery, problem based learning etc.), student competence and intelligence profile, improved collaboration, new teacher roles, and social contexts bearing in mind that IT in itself does not improve pedagogy and learning method.

- Higher demands on teacher competence in connection with specification of distributed learning system and tools. IT-tools and knowledge representations used must be (at least implicitly) described to the learner.
- High accessibility to vast information and a great variety of ICT-tools makes higher demands on teachers to model learning contexts (who, when, where, why), social interaction and users expectations and abilities – situated action (Suchman 1987).
- Take into account student prerequisite and competences in course development.
- Specify minimum requirements on students learning tools equipment.
- Plan for relation to other courses within the educational institution (one or many universities involved).
- Provide for a good balance between student/teacher presence in physical and virtual learning spaces.
- Secure a realistic balance between available time, available resources and level of ambition in course realizations.

4.3 Learning material production and storage

The distributed IT-supported learning environment poses new challenges to teachers in developing new courses and re-engineering old ones. New working methods are introduced as well as new routines for course maintenance, changes in learning methods and pedagogies, and development of efficient collaboration within and between universities.

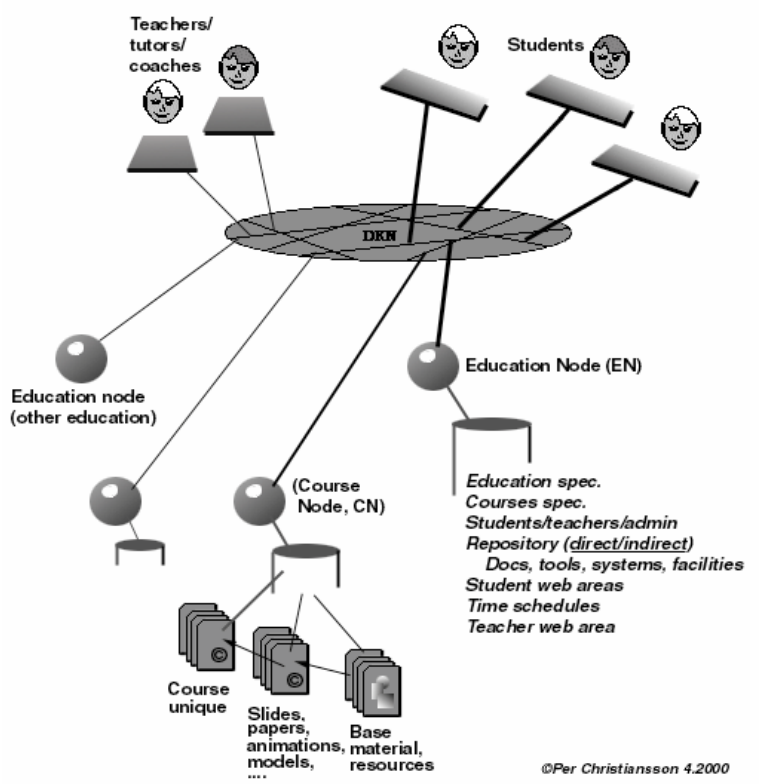


FIG. 7: Students main education access is through the Education Node, EN. If all traffic is channelled through EN it is easier to create administrative data as 'who-is-on' and 'when', and 'who has accessed what. This is in conflict though with student direct access to teacher produced locally stored material. From (Christiansson, 2000).

It is tempting and natural to create a web of learning material that continuously is improved based on updates of only low level information chunks. Ordinary books form a self-contained unit where presentation and storage medium is static and as a whole revised to new versions (editions). Figure 7 indicates that a teacher can create chunks of general slides and learning material that can be updated independently and together form/link to a dynamic 'book'/course material (the CN node). It is natural that learning material produced and maintained

resides 'near' the creator (in a creator controlled domain). From a curriculum administrator view this may seem inefficient and will mean that specifications of meta level access structures and content descriptions must be established to assure smooth student access to learning material. Semantic Web approaches will in the future support this distributed, not centralized, view on handling learning material, and of course corresponding resource allocation to secure meta level administration. Coordination on international level will be required when educations involve several countries.

We must also already now define university library long-term storage functions and routines to acquire and handle sealed versions of digital information containers. This is probably already in many cases a legal condition. The migration of produced digital material to public library level is considerably faster today when information is not filtered and packed in books in the traditional way. Libraries on all levels become more virtual and may have to be re-defined in terms of information access and delivery mechanisms, information quality assurance, information back-up, version handling, access rights and costs, and staff financing.

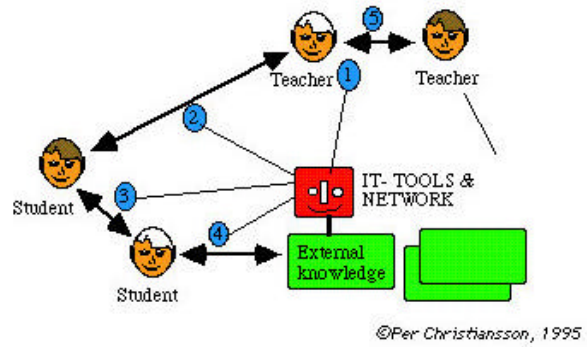
My personal view is that it should be possible to trace the development of courses and that learning material should be dated to reflect what students learned at a certain time, that is, the course contents and references should be maintained in that year course edition. However 'slides' linked to lecture notes may due to efficiency demands be, updated, but could besides '/latest update/, (previous update), [creation date] have internal date marks for updated contents to reflect progression.

It is important that each 'knowledge node' in an educational network has a *responsible* 'publisher'. If references/links are made to external web containers it often happens though that the contents are removed or renamed. This may require local storage within the course node of referenced material not produced at the publisher site. That is a local copy of the document is stored on the course node, CN, to ensure access even if the referenced original is removed. Copyright issues must then be cleared out. See also figure 7.

It is also important to ensure that learning material is stored under a format that is valid on many computer platforms. For example, PDF or RTF formats should be used for documents, web pages should be cleared from platform specific non-standard script contents, and standard video sound formats used. This may not always be possible if specific applications are still only available on some platforms. Students should also be encouraged to avoid fancy non-necessary solutions when reporting or delivering computer based project/exercises solutions.

5. THE LEARNING PROCESS

5.1 The Actors



ACTORS AND TOOLS RELATIONS IN THE LEARNING PROCESS

(1) The teacher/turor personal tools
(2) Student teacher/tutor interaction tools
(3) Student collaboration tools
(4) Student access to external knowledge
(5) Teacher/tutor interaction tools

FIG. 8: Student, teacher/tutor ICT support tools in the learning process, (Christiansson 2000).

The main actors in the learning process are the students supported by teacher/tutors and ICT tools. The less developed tools today are support for distributed project work and collaboration. Figure 8 provides a map

showing where IT can support communication in a distributed learning environment. The learning activities go on in rooms/spaces aimed for personal work, group work, lectures and whole course/class activities. ICT-tools will support personal communication and provide communication support with educational artefacts. It should be possible to

- Create personal, group, and course rooms/spaces (physical and virtual) as well a social meeting places.
- Create separate working areas within the mentioned spaces
- Ensure communication bandwidth capacity and network functionality (QoS, Quality of Services) for chosen information contents and communication requirements,
- Provide access to physical and logically shielded nets from home, company, permanent/temporary university group workplaces
- 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).

5.2 Learning styles

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 in mid-1400 (Guthenberg) and it became practical and less expensive to pack and distribute information to a large audience. Today we phase a reality where we (teachers, students) have the freedom to immediately publish, give feed-back and pack information adapted to different needs and users on the World Wide Web (WWW). We have thus passed the stages from 'art of writing' via 'art of printing' (1450 a.c.) to the 'art of communication (2000 a.c.) with changed demands on information quality assurance methods and separation of information storage and access media.

Learning theories are multitude and research related to many science domains such as psychology, cognition, social sciences, philosophy, and medicine. Here we shall focus on some explanations with certain relevance to ICT supported learning.

Different learner characteristics can be defined. From (Montgomery 1995)

- Processing (Active/Reflective)
  Active learners learn best by doing something physical with the information, while reflective learners do the processing in their heads.
- Perception (Sensing/Intuitive)
  Sensors prefer data and facts, intuitors prefer theories and interpretations of factual information.
- Input (Visual/Verbal)
  Visual learners prefer charts, diagrams and pictures, while verbal learners prefer the spoken word
- Understanding (Sequential/Global)
  Sequential learners make linear connections between individual steps easily. While global learners must get the "big picture" before the individual pieces fall into place.

The results of a survey of student learning styles are also reported

- -67%of the students learn best actively, yet lectures are typically passive;
- 57%of the students are sensors, yet we teach them intuitively;
- 69%of the students are visual, yet lectures are primarily verbal;
- 28%of the students are global, yet we seldom focus on the ‘‘big picture.

As expected, the example emphasizes that we have to harmonize the course material to different types of student minds and learning styles. Our possibilities to provide tools that suit different learning styles should be taken into account as we develop ICT supported learning material. The user models are explicitly or more often implicitly hidden in the computer system providing different pedagogical approach and human computer interaction.

In 1983, Howard Gardner introduced his Theory of Multiple Intelligence in the book Frames of Mind. Gardener states (Gardner, 2003), "In my own "theory of multiple intelligences," I argue that human beings have evolved to be able to carry out at least seven separate forms of analysis:

1. Linguistic intelligence (as in a poet);
2. Logical-mathematical intelligence (as in a scientist);
3. Musical intelligence (as in a composer);
4. Spatial intelligence (as in a sculptor or airplane pilot);
5. Bodily kinesthetic intelligence (as in an athlete or dancer);
6. Interpersonal intelligence (as in a salesman or teacher);
7. Intrapersonal intelligence (exhibited by individuals with accurate views of themselves)"

In education there has been a tendency to emphasize the logical-mathematical and verbal-linguistic intelligences in learning process. ICT supported learning gives us possibilities to better adapt learning material and pedagogy (according to Merriam-Webster - Pedagogy: the art, science, or profession of teaching) and learning styles to different intelligence profiles also taking into consideration that the different personal intelligence can be further developed through training.

Today you often see reference to four (three) learning styles namely, see also
http://www.metamath.com/lsweb/fourls.htm
(and test yourself at http://www.metamath.com/multiple/multiple_choice_questions.cgi)

- The *Visual/Verbal* Learning Style (learns best when information is presented visually and in a written language format. Like to study by yourself in a quiet room)
- The *Visual/Nonverbal* Learning Style (learns best when information is presented visually and in a picture or design format. Likes film, videos, maps, and charts in classroom settings and tends to like to work in a quiet room and may not like to work in study groups. May have an artistic side)
- The *Tactile/Kinesthetic* Learning Style (learns best when physically engaged in a "hands on" activity, classroom demonstration and field work outside the classroom)
- The *Auditory/Verbal* Learning Style (learns best when information is presented auditory in oral language format. Likes group discussions. Likes to interact with others in a listening/speaking exchange)

The Experiential Learning theory by Kolb from 1984 (Kolb, 2004) has been influential on learning theory development though also criticized by some. Kolb defines four learning models (behaviour) - Accommodator, Diverger, Assimilator and Converger and their relations to four learning styles Concrete Experience, Reflective Observation, Abstract Concepualisation, and Active Experimentation, see figure 9 and (Kolb et al., 1999).

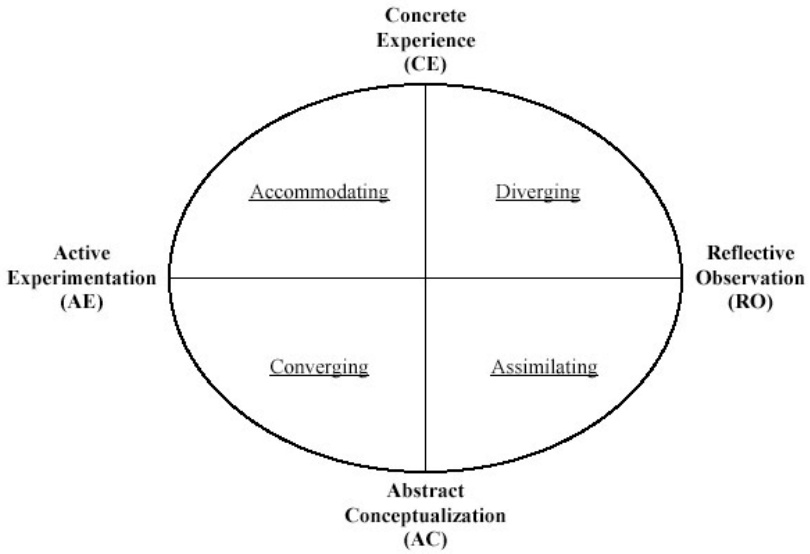


FIG 9: The Experiential Leaning Cycle and Basic Learning Styles -Kolb, 1984. From (Kolb, 1999)

Diverging learning style persons like brainstorm, broad cultural interest, like to gather information and work in groups). *Assimilating* style persons prefer information put in concise, logical form and are interested in ideas and abstract concepts. In the learning situation they prefer reading, lectures, exploiting analytical models and time to think through. *Converging* style persons like to deal with technical tasks and problems. The *Accommodating* style persons enjoy challenging experiments and acting on "gut" feelings rather logical analysis. Accommodating learning style also persons prefer to work with others to get assignments done, to set goals, to do field work, and to test out different approaches for completing a project. (Kolb, 1999).

Kolb further states "ELT /Experiential Learning Theory/ follows Carl Jung in recognizing that learning styles result from individuals' preferred ways for adapting in the world. Jung's Extraversion/Introversion dialectical dimension as measured by the Myers-Briggs Type Indicator (MBTI) correlates with the Active/Reflective dialectic of ELT as measured by the LSI; and the MBTI Feeling/Thinking dimension correlates with the LSI Concrete Experience/ Abstract Conceptualization dimension. The MBTI Sensing type is associated with the LSI Accommodating learning style and the MBTI Intuitive type with the LSI /Learning Style Inventory/ Assimilating style. MBTI Feeling types correspond to LSI Diverging learning styles and Thinking types to Converging styles. The above discussion implies that the Accommodating learning style is the *Extroverted Sensing* type, and the Converging style the *Extroverted Thinking* type. The Assimilating learning style corresponds to the *Introverted Intuitive* personality type and the Diverging style to the *Introverted Feeling* type. Myers descriptions of these MBTI types are very similar to the corresponding LSI learning styles as described by ELT".

Myers_Briggs Type Indicator (MBTI). The dichotomies Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling, and Judging-Perceiving can be combined in 16 ways to describe a person's personality. The MBTI is based upon Carl Jung's notions of psychological types. The MBTI was first developed by Isabel Briggs Myers (1897-1979) and her mother, Katharine Cook Briggs. See (MBTI, 2004)

5.3 Project oriented problem based learning

The PPBL, Project and Problem Based Learning, methodology was introduced 1974 at Aalborg University. From (Kjærsdam 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 programs the project work is mainly design-oriented. The last two years in the graduate programs the project work is mainly problem-oriented (Problem Based Learning). ..... The duration of each project is one semester. In the program 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.". See also figure 10.

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 in that 80% of the students pass their examination at the prescribed time.

ICT-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 co-operative 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.

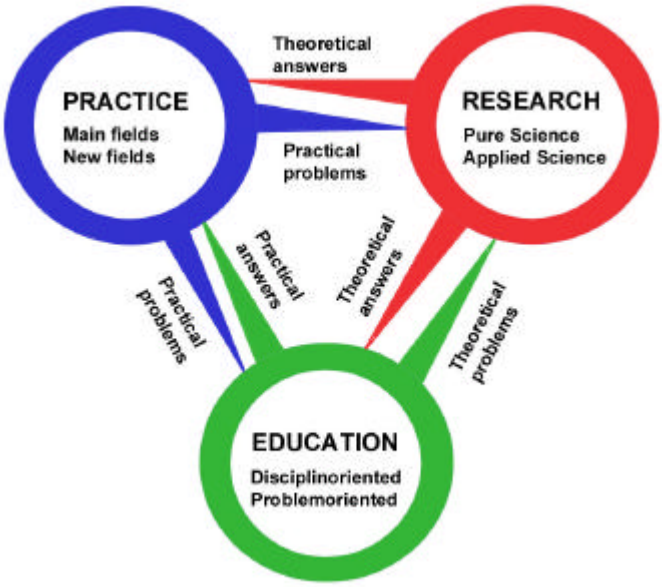


FIG. 10: The dynamic model of the relationships between practice, research and education. From (Kjærsdam & Enemark, 1994)

"Extensive research has shown that students learn best when they perceive a clear need to know the material being taught. Project/problem-based learning (PBL) utilizes this principle by introducing course material on a just-in-time basis in the context of realistic engineering problems and projects.....Several entire universities have taken one form or another of PBL as the basis of *all* of their curricula, including the University of Aalborg in Denmark and Olin University in Massachusetts. " (Felder, 2004). However, Felder states that is a slow process of leaving the teacher-centred approach in engineering education.

5.4 Practical experiences

From '5.2 Learning Style' chapter it is clear that we must provide a learning environment that meets the requirements from a broad spectrum of student related learning styles. We try to combine the four learning styles Visual/verbal, Visual/Nonverbal, Tactile/Kinesthetic, and Auditory/Verbal in the learning environment set-up and learning material content. Courses are given at the university (civil engineering) and in a distributed environment (Master of Industrial IT), see also <http://it.bt.aau.dk/it/education/index.html>.

We give two types of courses, SU (study unit) covering 25% of available time and PU (project unit) covering 25%. The rest of the time is devoted to project work in groups of size 3-5 students. The PU courses are evaluated through the project exams (typically for the group together, 1 hour project presentation and an additional 1.5 hours maximum per student) with external censor present. SU course exams may take several forms - traditional 'paper based', or oral.

The learning paradigm follows the Aalborg Project Organised Problem Based Learning (PPBL) model. The project is problem oriented and not tied to a specific discipline, but requires a cross-disciplinary approach. The projects most often involve industry collaboration and offer opportunity to apply theories in new contexts or to develop new theories. There are not only one way to solve formulated problems.

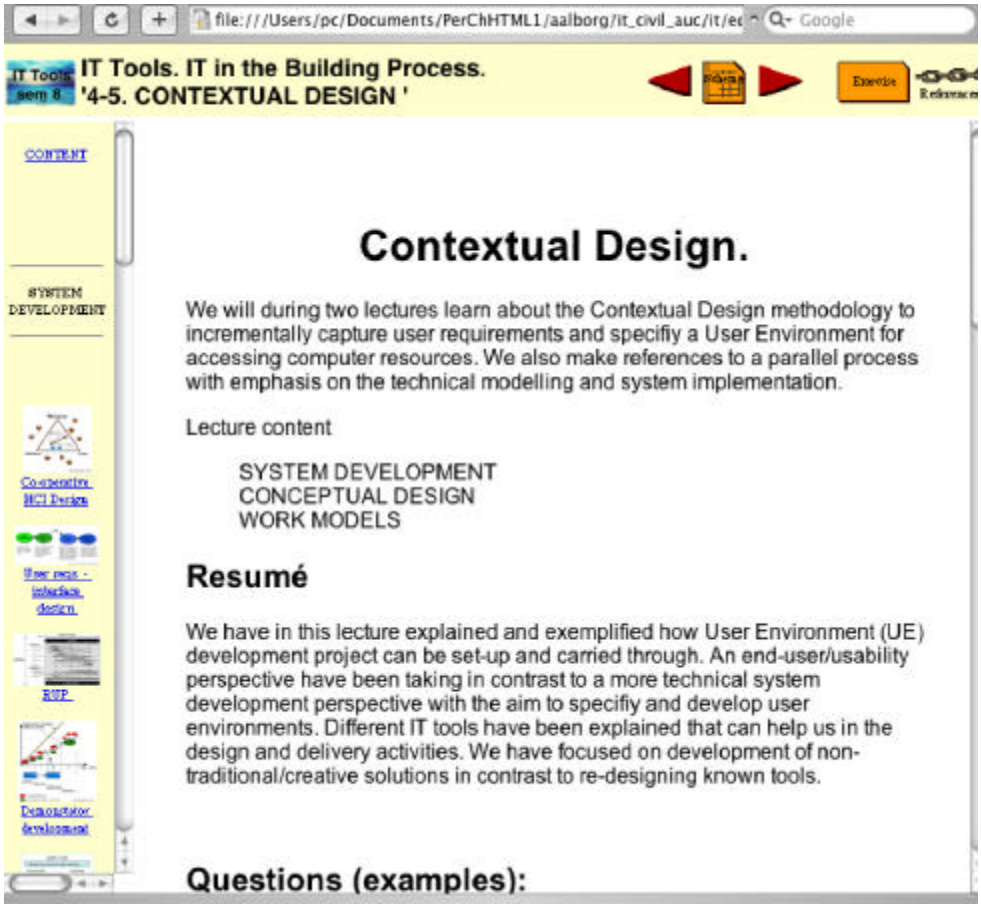


FIG. 11: Lecture material is contained in a in the course web with graphic/textual navigation frame to left.

In SU courses we normally plan a 4 hour session as

- 2*45 minutes lecture including 10 minutes exercises presentation
- Student group work with exercise work
- Student group exercise presentation in front of all groups followed by discussion, questions and critique

The students are during the group work forced to articulate and express their ideas and solution proposals to their colleagues and free to choose presentation format at their wish.

The lecture material is contained in a course web site with all learning material directly available except for books and documents not available in digital formats. Slides and other lecture support material are organised according to figure 11, with a left slide navigation column.

In the Master of Industrial IT, MI, course students are situated at different places in Denmark and meet in person at Aalborg University every six weeks at a *weekend seminar* for deeper social contacts, personal contact with course tutors, collective questions answering, guest lectures, group works, and final examines. New learning IT tools to support self-study, project work, self-assessments, project delivery, communication and course administration are also introduced on those occasions.

The students' first project is focused on transferring knowledge on the PPBL methodology and the supporting ICT tools. This pilot project is launched early during the first year, and accompanied and followed by a course block and finally concentrated project work.

Below some findings based on experiences from the MII and other ICT related courses are listed, see also (Christiansson, 1999) and (Christiansson, 2000)

- It is important to put introduction and use of ICT tools in construction in a historic perspective. It is a fact that we have a lot to learn from decades of modelling efforts with varying focus roughly every ten years on product modelling and user tools formalisation.
- As we are in a very creative phase of developing ICT supported learning always remember (teacher/tutors and students) to place in context facts, findings, ideas, and research on ICT tools and their use in a holistic view.
- Students still to a large extent want to read printed output rather than computer screens. One reason for this is that they are more familiar with annotating printed than digital writing.
- Students and teachers/tutors are not all familiar with the new potentials that IT -supported collaboration provides (e.g. groups continuously documenting project progress, and teachers using the student project web to follow progress).

- Discussion forums will not be used unless actively triggered by tutors.
- Teachers/tutors have to acquire new routines for distant tutoring and collaboration, progress follow up, and learning material production and dissemination.
- Teachers must be highly accessible tutors and problem solvers especially during project kick-off to make injections when group activities fade (search the problems). This poses special problems in a highly physically distributed environment.
- Student portable computers are winning ground in favour of stationary computers.
- It is an imposing challenge to build up positive attitudes to ICT supported learning approaches among traditional learning oriented teachers/tutors..
- Traditional guided exercises are an efficient ingredient to problem-based learning.
- Make learning material and student project work also from old courses available on the web. During a course though some student groups want to have intranets only available for the group (they see a risk for improper result spread before the project is finished).

6. THIS ITcon ISSUE

In this ITcon issue on ICT supported learning we present 6 papers covering a part of an extensive R&D area.

The first paper by Yehuda Kalay titled "*Virtual Learning Environments*" describes the underlying theories and efforts to develop virtual learning environments, and the software that allows users to access and inhabit them. Kalay among other things states "We propose that the socio-cultural advantages of place-based learning can be combined with the efficiency of ‘remote learning’ if we used architecture as the metaphor for creating the virtual learning environment, rather than the prevailing document metaphor."

In the paper "*Educated by Design - Learning by doing. Outline of a HCI-Didactics*" Ellen Christiansen delves on the question 'What is the right mix of workshop-learning and lectures, e-learning and face-to-face dialogue in teaching Human Computer Interaction at university level, where academic reflection is supposed to go hand in hand with learning basic skills in interface design and usability testing?' She outlines a didactic pattern for teaching Human-Computer Interaction based on experience from a course in Human Computer Interaction, and a paradigm as a tool to determine what type of knowledge to convey in what mode of interaction, in what kind of setting.

Joans Lindeman, Göran Sandberg, and Karl-Gunnar Olsson discuss in "*An approach to teaching architectural and engineering students utilizing computational mechanics software ForcePAD*" how courses in mechanics can be taught to architectural students in a manner aimed at presenting concepts in such a way that mechanics becomes a inspiration for the design process rather than a limitation to it. Experiences from use of the educational software ForcePAD is explained. The software is used to convey basic introduction in mechanics using intuitive understanding of physical matters related to mechanics and how that understanding can be transformed into design sketches.

In the paper "*Application of ICT Supported Learning in Fluid Mechanics*" Henrik Brohus and Kjeld Svidt focuses on the application of ICT supported learning in the area of fluid mechanics education. Taking a starting point in a course in Ventilation Technology, including room airflow and contaminant distribution, they explain how ICT may be used actively in the learning environment to increase efficiency in the learning process. A model for a combined use of several learning tools is also presented. The model describes the teaching method

and the pedagogical means. It explains how different learning domains – physical as virtual – may be combined to form a high efficiency learning environment (HELE).

Danijel Rebolj and Karsten Menzel describes in their paper "*Another step towards a Virtual University in Construction IT*" a project started in 2001 involving nine Universities with the aim to develop an interuniversity postgraduate program in Construction Information Technology. The students attend the subjects in different ways: face-to-face at home universities, face-to-face at partner universities, as well as by means of open and distant learning. The paper describes the background, the teaching experiment itself, the observations made, and the specification of an integral distant learning environment, as a framework of a future Virtual University in Construction IT.

In the final paper "A Course on Computer-Aided Building Design" Hugues Rivard and Claude Bédard describes and report experiences of the evolvement over 20 years of a final-year undergraduate course in Computer-Aided Building Design. The course introduces students to the process of integrated building design. It emphasizes both computer assistance (CA) and building design (BD). Students experience the design process in teams in the context of a realistic building design project. The paper provides a brief historical overview of the course and it describes the material covered, the team-design project, and the IT portion of the course.

7. CONCLUSIONS

It is a well documented (unfortunately) truth that the development within didactics has been very gentle during the latest centuries. We are now facing a dramatic shift in development speed as ICT tools are introduced on a large scale. ICT supported learning development has come into focus during the latter decades and originate from progress in engineering analyses and simulation software, information handling systems, and advanced human computer interaction designs. Lately, the development has taken a quantum leap due to standardisation and global spread of the Internet based applications and communication support. We are in fact right now in the middle of an intense development phase where creative ideas on ICT tools and tools to design tools (meta tools) as well as new organisation of the learning environment and enhanced pedagogical methods are tried out.

We are only in the beginning of development of cross-disciplinary university courses in open environments with access to highly communicative ICT tools in contrast to traditional classroom based teaching and learning. This is a creative change process involving all actors in the learning process with a constant trade-off and balance between technology driven change of learning processes, pure inclusion in existing learning processes of new ICT tools, and implementation and evaluation of changed learning paradigms.

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 as well as build up of curricula involving several universities.

There is a great need to raise the IT competence of the teachers and university administrations to meet the needs for and carrying through of 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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