Life long learning for improved product and process modeling support

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ABSTRACT:

The paper focuses on knowledge transfer and learning based on experiences from developing and carrying through master courses in Industrial IT (MII) and civil engineering at Aalborg University and 25 years of teaching experiences within the field. In the MII the students are recruited from industry to follow a 3 year 1/2 time national open education with most learning and project work done in an Internet supported distributed environment. The pedagogic method follows a project-based problem oriented learning paradigm (PPBL). The courses cover areas such as; object oriented programming and relational database design, human computer interface and user environment design, computer supported collaborative working, knowledge management, virtual buildings, intelligent buildings, and building systems simulation.

Experiences are reported from use of distributed physical and virtual learning spaces, improved learning styles and learning/teaching methods, properties and functionality of digital learning material, improved and adapted pedagogic, tutoring and teacher-student interaction, distributed project collaboration methodology, and industry collaboration. Findings and experiences are illustrated with examples from MII course contents and student project works.

1 INTRODUCTION

Information and Communication Technology (ICT) supported learning has come more and more in focus during the last 2-3 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. We phase a multitude of challenges in introducing efficient ICT support in the building process from change of working methods, project organisation and improved building product descriptions to increased demand on life-long learning within the fast developing building informatics.

The paper focuses on knowledge transfer and learning based on experiences from developing and carrying through master courses in Industrial IT (MII) and civil engineering at Aalborg University and 25 years of teaching experiences within the field. In the MII the students are recruited from industry to follow a 3 year 1/2 time national open education with most learning and project work done in an Internet supported distributed environment. The pedagogic method follows a project-based problem oriented learning paradigm (PPBL). The courses cover areas such as; object oriented programming and relational database design, human computer interface and user environment design, computer supported collaborative working, knowledge management, virtual buildings, intelligent buildings, and building systems simulation.

Courses given within Building Informatics at Aalborg University incorporate results from the teacher's involvement in ongoing research such as knowledge management and collaboration support using semantic web, IT Support at the Building Site and involvement in the newly started Danish National Digital construction Program (clients' demands on building modelling and visualisation, project web support and facility management), see also http://it.civil.auc.dk/it/projects/index.html.

2 THE CHANGE PROCESS

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. Today we phase a reality where we (teachers, students) have the freedom to immediately publish, give feed-back and pack information adapted for different needs and users on the World Wide Web (WWW). We have passed development stages from 'art of writing' (2500 b.b.) via 'art of printing' (1450 a.c.) to 'art of communication (2000 a.c.) with changed demands on information quality assurance methods, and highly adaptable access media to distributed digital information containers.

The most important changes due to introduction of ICT in the learning process are

- Higher emphasis on *learning* (and learning to learn) than teaching.
- The teacher becomes more of a *tutor* (coach, facilitator) than information disseminator.
- Greater opportunities for distant learning in *virtual environments.*
- Life *long learning becomes* an important issue (time and place independent learning).
- *Globalization* with cultural diversity and global market place development with greater possibilities to combine courses from different universities (*virtual* universities)
- Increased *modularization* of information containers with dynamic formation of higher level containers and inclusion of time marked data. The semantic web provides a first generation tools to relate disperse web based information containers, (Christiansson 2003)
- Possibilities to adapt and/or develop *new pedagogical methods/learning styles* with respect to learning material, 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.

3 IT IN CONSTRUCTION LEARNING DOMAINS

Computer tools were introduced in the education during the mid 1960s. Our IT education 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" at Lund University, Sweden,
- 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",
- 1995 "To use and evaluate MultiMedia", and "Make your own MultiMedia Application"

Information and Communication Technology (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. relational database and relation algebra based representations. On the other hand many areas are still under formalization and learning material and courses must be dynamically composed leading to continuous update and development of courses. Figure 1 outlines building informatics related knowledge domains.

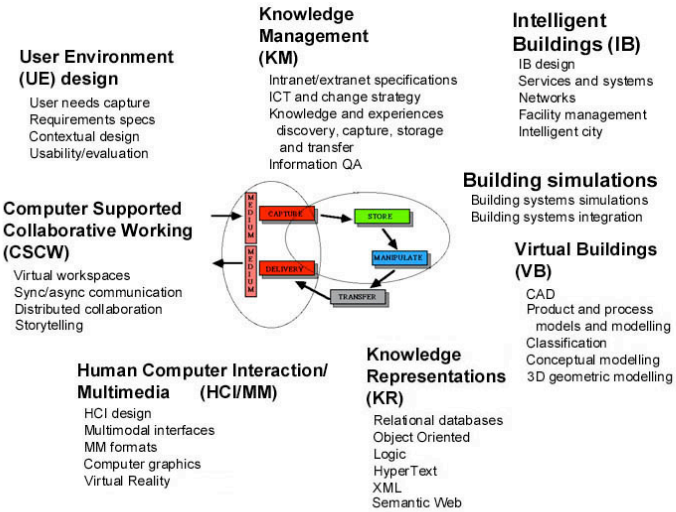

Figure 1. IT in Construction learning domains

4 LEARNING PARADIGM

Our possibilities to provide tools that suite 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. Learning theories are multitude and research related to many science domains such as psychology, cognition, social sciences, philosophy, and medicine. Here we will focus on some explanations with certain relevance to ICT supported learning, see also (Montgomery, 1995), (Gardner, 2003), and (Kolb et.al. 2004).

The learning environment should as far as possible support different learning styles involving concrete experiences, reflective observations, abstract conceptualization, and active experimentation (Kolb et.al. 2003) also taking into account that students have different preferences on the way information is accessed. Today you often see reference to four (three) learning styles namely, see also http://www.metamath.com/lsweb/fourls.htm, Visual/Verbal, Visual/Nonverbal, Tactile/Kinesthetic, and Auditory/Verbal.

4.1 *PPBL*

The PPBL, Project Organized 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."

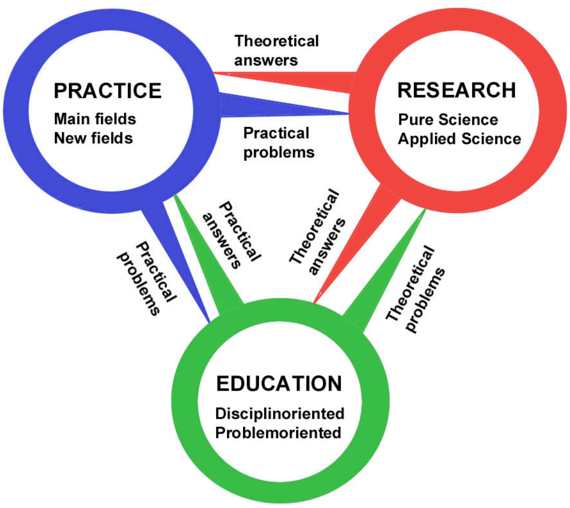

Figure 2. The dynamic model of the relationships between practice, research, and education. From (Kjærsdam & enemark)

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

The learning paradigm follows the Aalborg PPBL, Project Organized Problem Based Learning, 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.

We normally plan a 4 hours session in the SU courses 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.

5 LEARNING ENVIRONMENT

5.1 *Physical and Virtual Workspaces*

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

From (Christiansson 1999) “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”.

5.2 *Tools and infrastructure*

The ICT tools broadly falls within the following categories

- *Human Computer Interaction* (HCI) with multimodal access to dynamically composed information containers and applications
- *Communication and collaboration* support (human-human, human-artifact, artifact-artifact)

- Digital *information containers* with modularised content and separation between storage and access media

The students have at their convenience, access to course administrated servers for their project programming work, see figure 3.. The student project results as well as learning material are stored on (or referenced from) a education web.

Asynchronous collaboration tools are provided on the education web. Student groups also use tools like Groove, http://www.groove.net, Yahoo Messenger http://messenger.yahoo.com/, and MSN Messenger (former Netmeeting) http://www.microsoft.com/messanger, for synchronous collaboration and application sharing. Teacher/tutors are often on student group wishes on stand-by at student email conversation and available for advice.

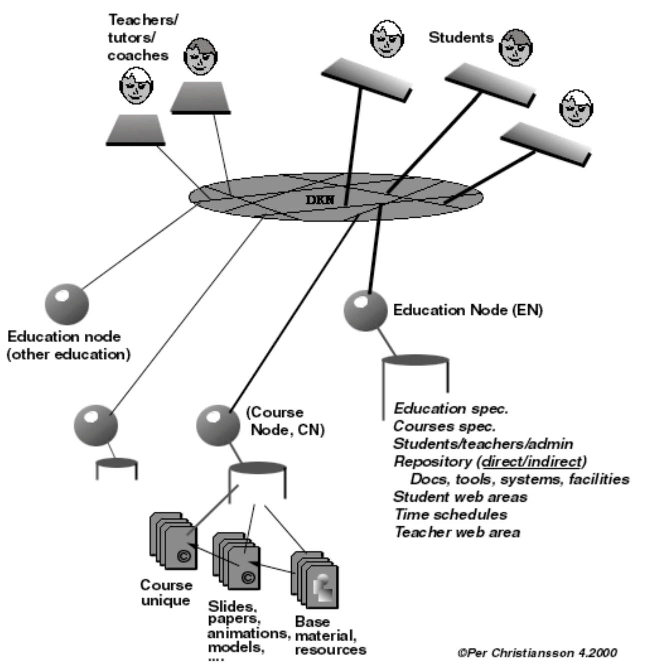

Figure 3. Students main education access is through the Education Node, EN. If all traffic is channelled through EN it is easier to create administrative data as 'who-is-on' and 'when', and 'who has accessed what'. This is though in conflict with direct student access to teacher produced locally stored material. From (Christiansson, 2000).

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

5.3 *Learning Material*

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 organized according to figure 4, with a left slide navigation column.

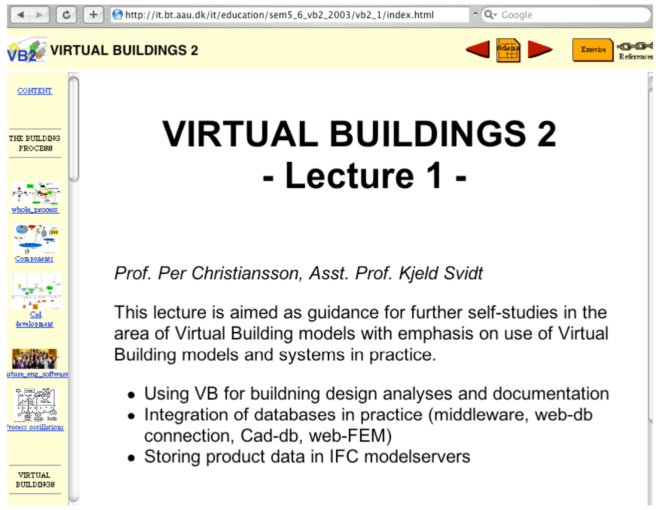

Figure 4. Lecture material is contained in a in the course web with graphic/textual navigation frame to left.

The course material is accessed from the education web, EN in figure 3, that also gives access to student project work and administrative courses information.

6 COURSE CONTENT

6.1 *Master of Industrial IT courses*

Courses given to the Civil engineering students within Building Informatics as well as the Master and Industrial IT (MII) courses, http://www.mii.aau.dk, covers the domains depicted in figure 1. The Civil engineering courses will not be described here but can be found at http://it.bt.aau.dk/it/education/index.html#civil as well as student projects and student own developed project webs. Three courses are given at the Civil Engineering track (1) IT in the Building Process, (2) Virtual Buildings, and (3) Computer Supported Collaboration and User Environment Design.

The MII education spans 3 years half time (from autumn 2004 compressed to 2 years) and is open for students with a Bachelor Engineering degree and at least 3 years of industry employment. The first year theme is 'Distributed Information systems' and is followed by all students in the three specializations,

- IT in Construction
- IT in Distributed Real-time Systems
- IT in Industrial Production

- IT in Process control
- IT in System Administration

First year courses are

- Object Oriented System development, (2 ECTS, PU course)
- Human Computer Interaction (1 ECTS, PU)
- Databases (2 ECTS, PU)
- Fundamental Datanets, Models and Architecture (1 ECTS, SU)
- Client/server technology and introduction to Distributed Systems (2 ECTS, PU)
- WWW tools (1 ECTS, PU)
- Programming (2.5 ECTS, PU) (optional for IT in Construction)
- The Virtual workplace (1 ECTS, PU)

The second year IT in Construction theme is 'Models and Communication' and the special building related courses

- Multimedia interface design, usability engineering and Computer Supported Collaborative Work (2 ECTS, PU)
- Knowledge Management within Companies and Projects (2 ECTS, SU)
- Virtual Buildings 1 (1 ECTS, PU)

The third year IT in Construction theme is 'Integrated ICT in the Building Process' and the special building related courses

- Intelligent Buildings and Digital Cities (2 ECTS, SU)
- Virtual Buildings 2 (2 ECTS, PU)
- Building Simulations (2 ECTS, PU)

The students will also, according to their personal course portfolio, follow other specialization's courses during the second and third year for example

- Global Information Networks
- Company Management
- Process engineering
- Organisation theory
- Distributed systems
- Automatic control
- Real-time communication systems
- Fault tolerant systems
- Coding and Security

The IT in Construction specialization gives insight into the role of ICT in the total building process. The participants will gain understanding of and competence in using ICT tools within all phases of the existing and future building process.

The participants will be able to formulate requirements and actively participate in analyses, design and development of ICT systems and tools in the construction process as well as practical experiences in use of advanced IT tools.

The theme for the 2nd year is 'Models and Communication'. The aim is to convey theoretical knowledge and deep understanding of some important fundamental domains and ICT-tools that will influence the future development e.g. computer supported collaboration, different types of knowledge representations, analyses and modeling of the building process and building products, and knowledge management.

High emphasis is on user needs, requirements formulation and usability engineering i.e. user environment design in relation to the parallel technical system implementation.

The theme for the 3rd year is 'Integrated IT in the Building Process'. The aim is to convey analyses, experiences and examples on advanced present and future use of IT in the different parts of the building process. In this connection the students e.g. work with and analyses building product model exchange using IFC and model checker tools. Also the properties and practical design issues in connection with intelligent buildings and services in the digital cities are investigated.

6.2 *Student Project Examples*

The student project work always to some degree involves industry collaboration. In many cases the students own company is highly involved in problem and requirements formulations. Examples on students group projects are, see also http://it.bt.aau.dk/it/education/index.html#mii

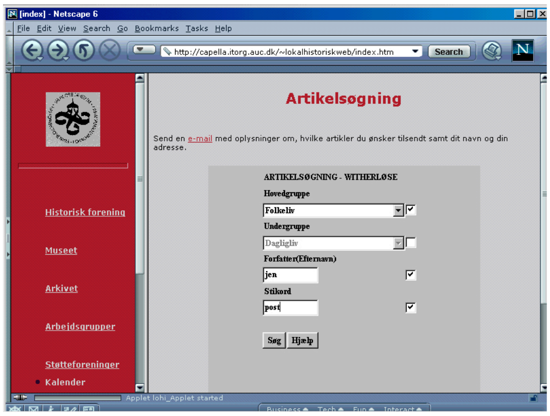

Figure 5. Java applet-servlet based web-database connection (student project)

- "Loacal history Web", 2001, involving Java based web-database connection for inquires of historic subjects. (Figure 5)
- Data Warehousing and Knowledge Management", 2001, involving theory, technology and implementation in business
- "Models and communication to support type house catalogues", 2002, involving Contextual Design of User environment, information analy-

ses, relational database and user interface design, web 3D models, and database web integration solutions. (Figure 6).

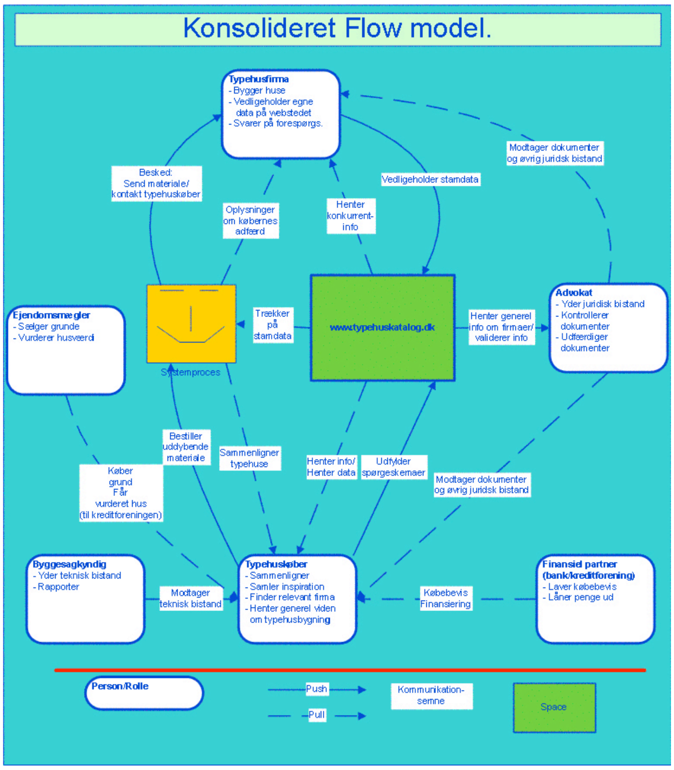

Figure 6. Contextual Design work flow model used for type house catalogue application (student project)

- "Use of digital building models", 2004, involving process analyses and representation, classifications, model access tools, building product model representations, model integration, potential/barriers, and scenarios.
- "Future digital cities and intelligent buildings", 2003, involving global networks, digital city networks and services, intelligent buildings, ICT solutions, scenarios and the future. (Figure 7)

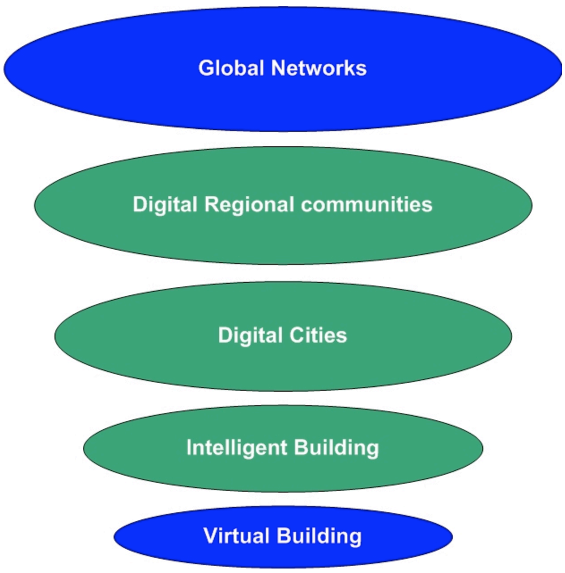

Figure 7. Digital cities intelligent and responsive building investigation domains (student project)

- "ICT tools for building design", 2004, involving analyses of architectural design tools in use. Requirements formulations on tools, education and design process organization.

7 CONCLUSIONS

We are only in the beginning of development of cross-disciplinary university courses in open environments with highly communicative IT tools in contrast to traditional classroom teaching. 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.
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 in connection with specification of distributed learning system and tools.

ICT tools and learning material knowledge representations and properties must be (at least implicitly) explained to the learners (and teachers/tutors).

ICT tools to support collaboration in virtual environments and use of virtual worlds and augmented reality must be further developed in close collaboration with the end users.

We will in the future see a closer natural collaboration between universities in course development, and experience exchange.

8 REFERENCES

Christiansson P. 2003 Next Generation Knowledge Management Systems for the Construction Industry. In CIB W78 Proceedings *Construction IT Bridging the Distance*, Auckland, New Zealand, April 23-25, ISBN 0-908689-71-3. CIB Publication 284. (494 pages). (pp. 80-87) http://it.civil.auc.dk/it/reports/w78_new_zealand_2003.pdf

Christiansson P. 2000. IT in Distributed Open Learning Environments". In *Construction Information Technology 2000 - Taking the Construction Industry into the 21st century*', G. Gudnason (ed.) Icelandic Building Research Institute. ISBN 9979-9174-3-1. Reykjavik, Iceland in June 26-30 , 2000. (pp. 197-208). http://it.civil.auc.dk/it/reports/r_iceland_6_2000.pdf

Christiansson P. 1999. Experiences from Design and Use of IT Supported Distributed Learning Environment. In *Civil Engineering Learning Technology in Cardiff*. R M Lloyd & C J Moore (eds). Thomas Telford Ltd. London.. ISBN: 0-7277-2839-3. (pp. 29-42). http://it.bt.aau.dk/it/reports/r_cardiff_edu_1999.pdf

Christiansson P, Herrera A, 1985. Datorstöd i Byggprocessen. Computer Aided Design. (Computer Aids in the Building Process. Cad Systems, Relational Databases, Knowledge Based Systems). Bärande Konstruktioner, und Unioversity. February 1985. (192 pp.).

Gardner H. 2003. Intelligence in Seven Steps. in *New Horizons for learning*. http://www.newhorizons.org/future/Creating_the_Future/crfut_gardner.html

Kjersdam, F., Enemark S. 1994. The Aalborg experiment. Aalborg. Project Innovation in University Education. *Aalborg Universitets Press*.

http://www.auc.dk/fak-tekn/aalborg/engelsk
Kolb D., Boyatzis R. E., Mainemelis C. 1999. Experiental Learning Theory: Previous Research and New Directions. *Prepared for Perspectives on cognitive learning, and thinking styles.* Sternberg R. J. & Zhang L. F. (eds) .Case Western Reserve University (40 pp) http://www.learningfromexperience.com/ELt_review_paper.pdf
Montgomery S. M., 1995, Addressing Diverse Learning Styles Through the Use of Multimedia. In *The 1995 ASEE/IEEE Frontiers in Education 95 Conference.* University of Michigan.