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BUILDING MANAGEMENT AND ICT LEARNING IN CIVIL ENGINEERING EDUCATION

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ABSTRACT

The paper presents structures of the learning domains of building informatics exemplified with experiences from building management civil engineering and open education in Industrial IT at Aalborg University. The courses cover areas such as; object oriented programming and relational database design, human computer interface, user environment design and usability engineering, computer supported collaborative working, knowledge management, virtual buildings, intelligent buildings, and building systems simulation.

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 learning model, PPBL. Experiences from present and possible future use 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 is also reported.

KEY WORDS

IT in construction, building informatics, education, distributed learning, industry collaboration, leaning styles, course content.

INTRODUCTION

There is at present and in the future building industry a great need for persons who can take active part in specification, design, implementation, and evaluation of tomorrows building process support systems. A broad view and insight into the complex building process together with a broad and in some key areas deep knowledge into existing and coming Information and Communication Technology (ICT) tools are required in combination. We phase a multitude of challenges in introducing efficient ICT support in the building process ranging from change of working methods, project organization and improved building product descriptions to increased demand on life-long learning within the fast developing building informatics domain.

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

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systems. 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.

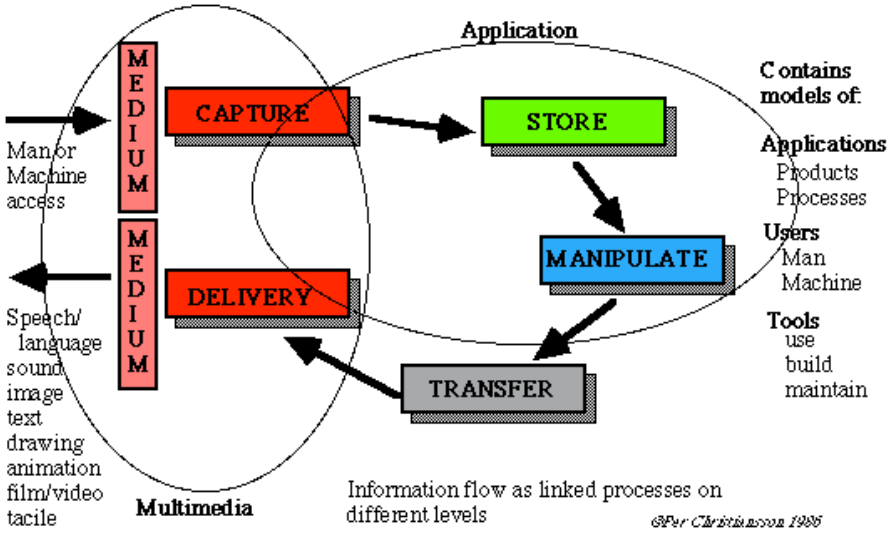

Figure 1: ICT (Information and Communication Technology) may be defined as the technologies to support capture, storage, manipulation, communication and delivery of information on different application levels (from macro to micro scale) and in different contexts such as technological, organisational, and cultural.

LEARNING PARADIGM

THE ART OF COMMUNICATION

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.c.) 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 and collaboration 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, see also (Berners Lee et al. 2001), (Christiansson 2003), and (LOM 2004).
- 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.

NEW COMPETENCES NEEDS

There is now and in the future building industry a great need for persons who can take active part in specification, design, implementation, and evaluation of tomorrows building process support systems. A broad view and insight into the complex building process together with a broad and in some key areas deep knowledge into existing and coming ICT tools are required in combination.

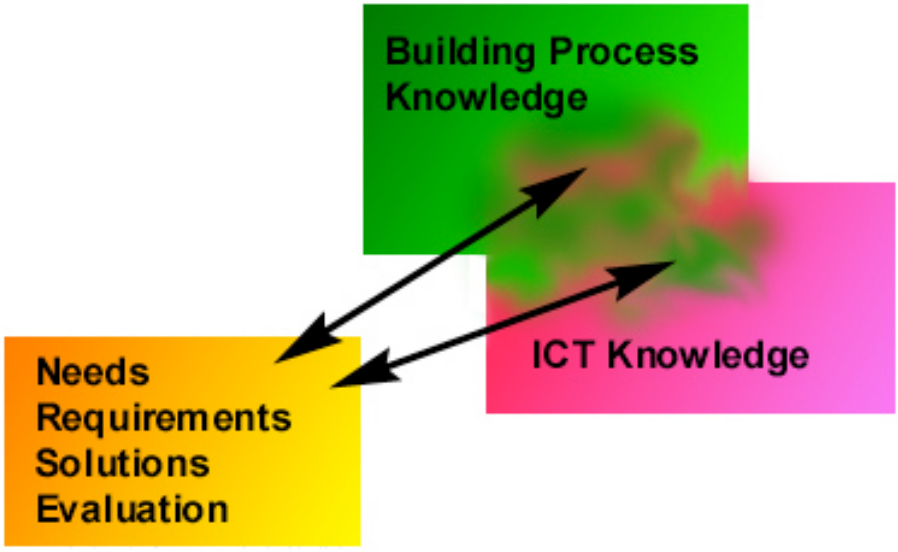

Figure 2: Builders must process some ICT competences to be able to formulate needs, requirements, and perform usability evaluation as well as to actively participate in the (creative) design of tomorrows building process ICT tools.

The complex project organization of the building industry together with higher international involvement will take great advantage of the future advanced ICT tools. The actual products will themselves also contain embedded and integrated IT support (Intelligent and responsive buildings). The building process will be more integrated, and supported by (often containing redundant information) product/process models. Information produced during the whole building project will to a higher degree support the maintenance and use of he final buildings and provide subsequent experience data.

We will through realistic simulations be able to get a much better support also as we make important decisions in the very early requirements formulation phase of the design process. We will increase our competence in specifying, designing, purchasing, building and maintaining the company IT systems. There will be increased need to formulate IT strategies to support the ongoing change process caused by design and introduction of new ICT supported tools.

The multimedia and virtual reality properties of the interfaces to the computer models of the building process and products will improve all the building process participants way to communicate and collaborate in distributed virtual collaboration spaces less constrained by time and geographic positioning.

The implementation in the building process has been rather slow due to

- the building process is one of the most *complex and less formalized* applied processes (short series of products, changing participants from project to project, changing production sites, cultural differences).
- Building process actors using *different* ICT tools, languages and model formalisms.
- Rich spectrum of *user interfaces* with different characteristics.
- Very *cross scientific* domain.
- Too little focus on building up it's own *ICT competences* (the out-sourcing trend increases the risk of loosen company business strategic knowledge).
- Low *client understanding* that ICT pays back (better early decisions in alternative solutions, higher quality and better documented end products.

LEARNING STYLES

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.

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. 1999) 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. (Christiansson, 2004b).

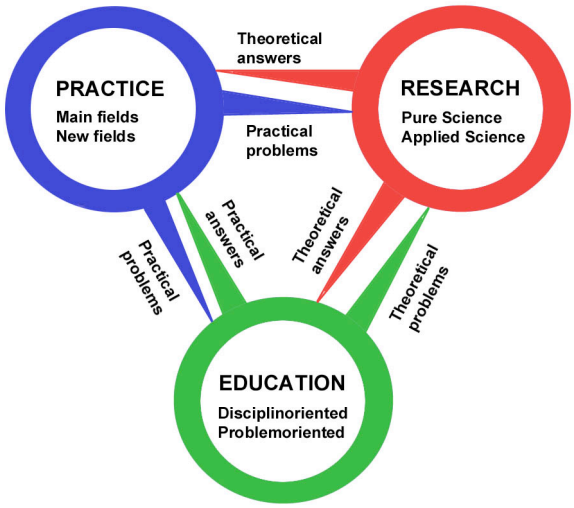

Figure 3: The dynamic model of the relationships between practice, research, and education. From (Kjærsdam & Enemark, 1994)

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."

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 devoted to project work in groups of size 3-5 students. The PU courses are evaluated through 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.

LEARNING SPACE AND LEARNING MATERIAL

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".

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 semina*r* 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.

In the Building Management civil engineering education the students have their own group rooms. Groups are formed every term and consist of 4-6 students. The students have their own computers (to a higher and higher extent portables) networked in the group rooms and to the Internet. They can work in virtual spaces supported by software for communication, collaboration, document handling and application sharing.

Figure 4: *Left*: The Panorama studio provides wide screen (if necessary in stereo mode) interactive access to computer applications for 25 persons. The leftmost image shows 3D analyses of complex heated airflow in a ventilated room. *Right*: 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

The students have at their convenience, access to course administrated servers for their project programming work, see figure 4. The student project results as well as learning material are stored on (or referenced from) the course or education web.

Asynchronous collaboration tools are provided on the education web. Student groups 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.

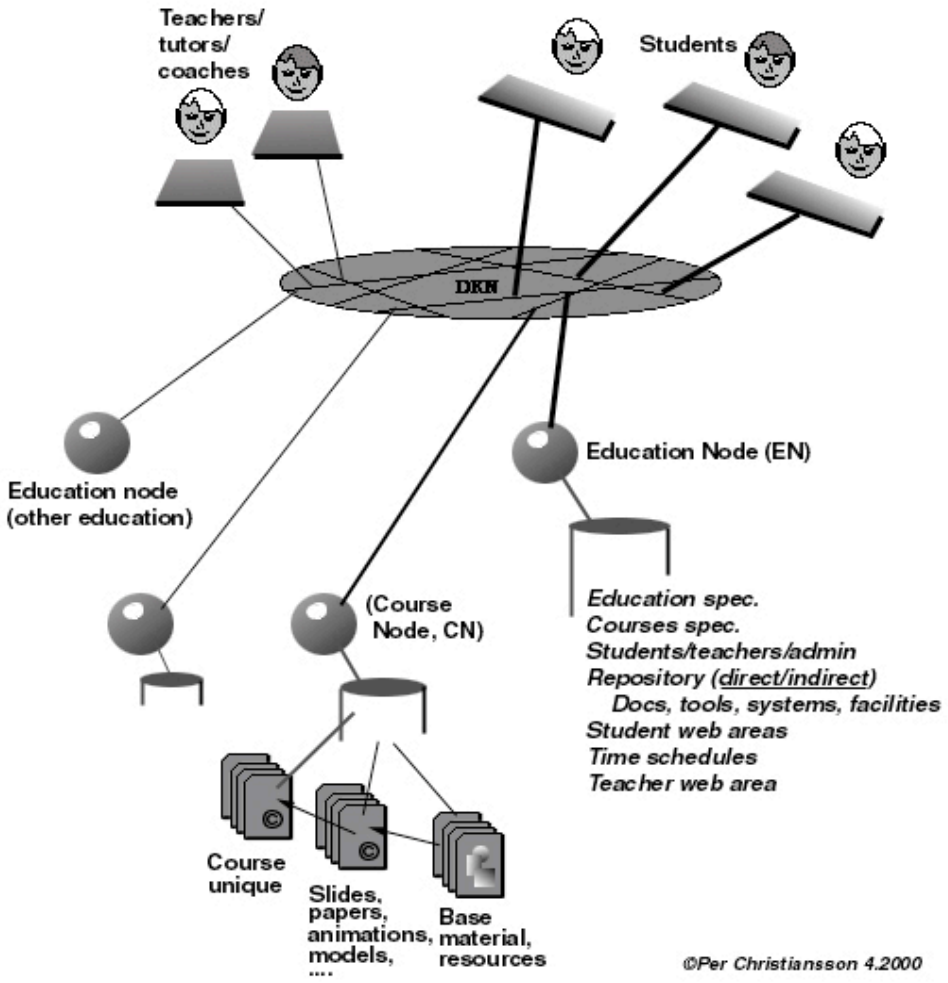

Figure 5: MII students main education access is through the Education Node, EN. If all traffic is channelled through EN it is easier to create administrative data as 'who-is-on' and 'when', and 'who has accessed what'. This is though in conflict with direct student access to teacher produced locally stored material. From (Christiansson, 2000).

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 is

- 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.

BUILDING INFORMATICS COURSES GOALS

The overall goals with introducing IT in the Civil Engineering curricula are

- Students should understand overall implications of working with digital information (on personal, team, project, and company levels) and the properties of logic information containers properties and building product- and process models.
- Students should understand the ongoing change processes caused by ICT introduction. This requires a holistic and broad view on the building process and the surrounding world.
- Students should be able to actively participate in the design of next generation digital building process environments and ICT tools.
- Students shall acquire deep knowledge within certain areas on design and adaptation of advanced ICT-tools as well as the relations between building process applications and ICT.
- Students shall be trained in and have deep knowledge in how ICT can serve to integrate competences (also outside the engineering domain) and artifacts in the building process and how knowledge can be efficiently captured and transferred.

It is not enough for the students to acquire surface knowledge about tools handling, without deep understanding of underlying phenomena, methods and theories. The risk is obvious that the civil engineers and Danish companies then will have problems to compete with foreign undertakings on a global work market. The project organised problem based learning paradigm utilized at Aalborg University gives the student good abilities to solve problems and work in groups but there is a risk for non effective learning due to repetitive routine project work.

Figure 6 outlines the overall knowledge domains that should be covered in the education.

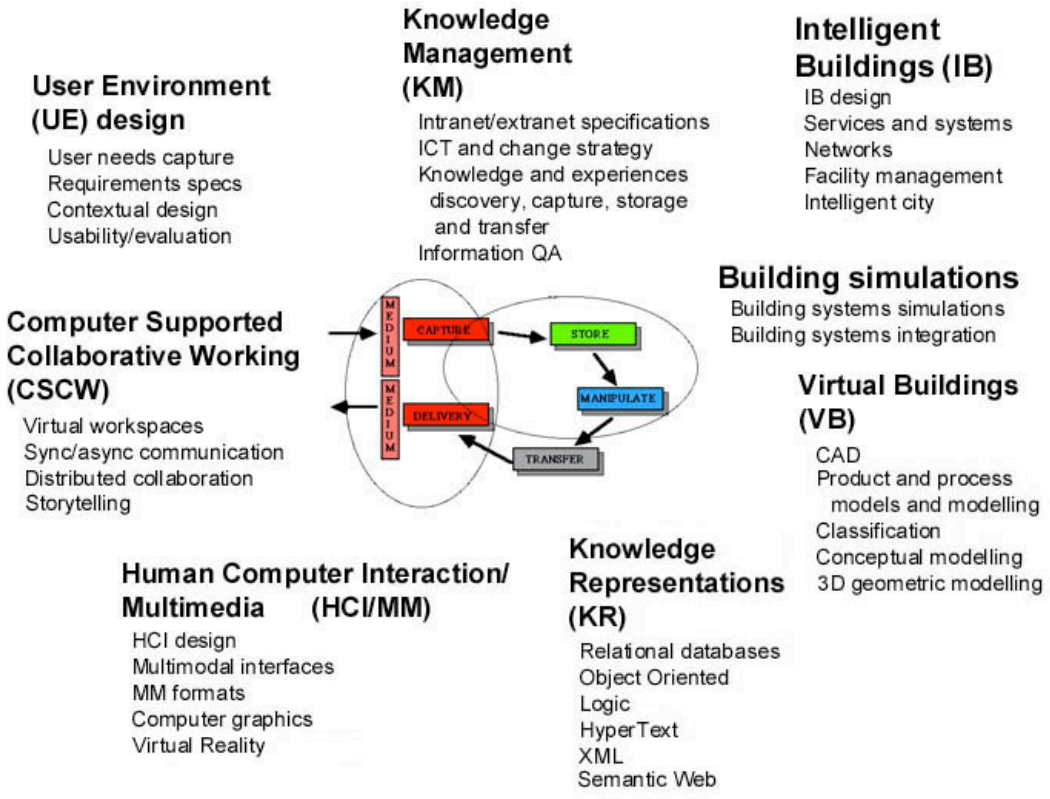

Figure 6: ICT in construction learning domains.

BUILDING MANAGEMENT ICT COURSES LAYOUT

The Building Management education (BM) forms a specialization of the civil engineering education during the last 2 years (terms 6-9) (of 4.5 years total).

During earlier terms the students learn to model relational databases, integrated cad in praxis, 3d-modelling, and project web design.

During semester 7-9 the curricula contains, except for the building informatics part, legal aspects of building, simulation of flow oriented systems, administrative systems, logistics, organizational behaviour, economy control, production concepts, project management, commercial law, integrated production, financial management, change management, quality control, and object oriented system programming.

We provide 2 courses in building informatics (See also figure 7, and http://it.bt.aau.dk/it/education/index.html#civil)

- Virtual Buildings
- Multimedia and knowledge management

The courses roughly falls within the right ('application') respectively the left ('multimedia') part of figure 1. The goal of the Virtual Building course is - 'to mediate knowledge about fundamental concepts, technologies and methods to analyse and develop models which

describe a building, the building process and the digital infrastructures from design to application as well as mediation of knowledge about how the future services, systems, and infrastructures for knowledge management can be built and integrated.' Special focus is on principles for meta-structuring in web based systems, project webs, knowledge representations, properties of the next generation Semantic Web (XML, RDF), Web database integration, conceptual and data modelling techniques, future structures of virtual building models, International Foundation Classes, IFC, and intelligent buildings.

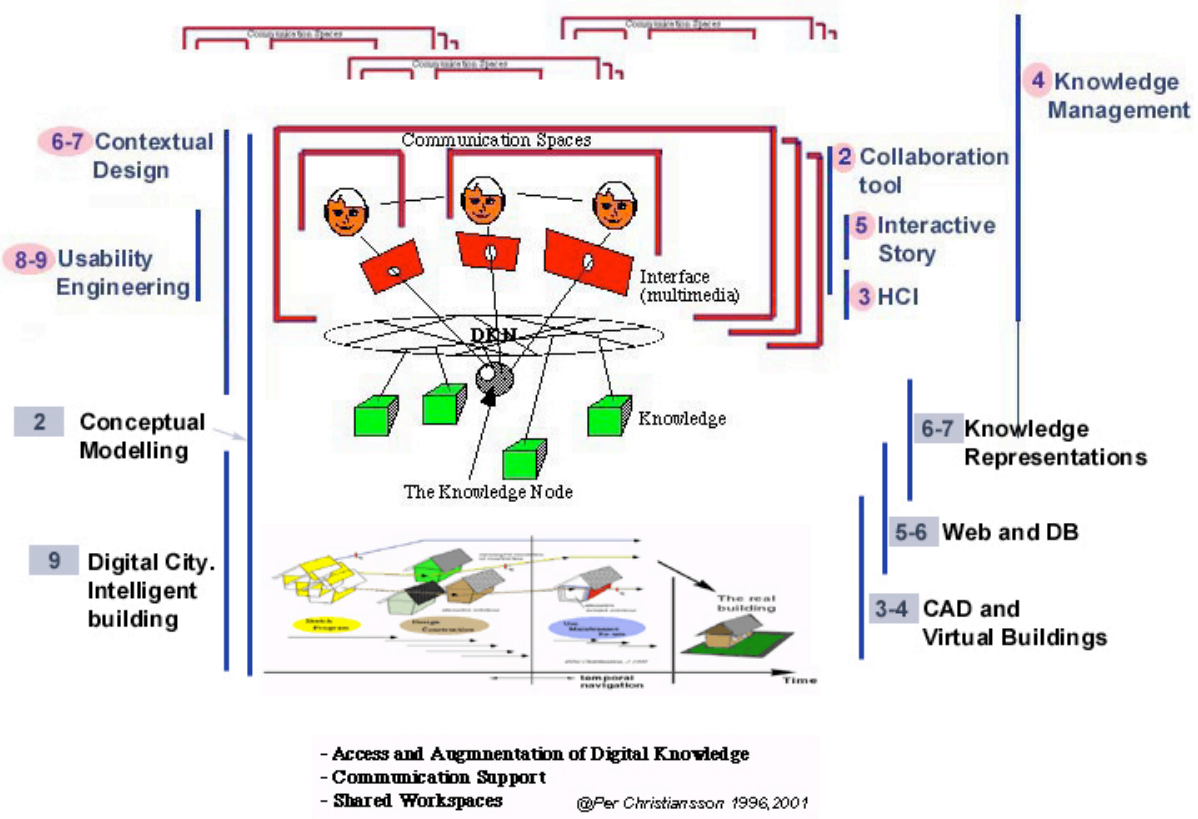

Figure 7 Building informatics courses at term 7 and 8 in the Building Management education. The lower part (with square lecture numbers) belongs to the Virtual Buildings course. The upper part (with oval lecture numbers) belongs to the Multimedia and Knowledge Management course.

The goal of Multimedia and Knowledge Management course is ' is to mediate understanding of principles, methods and technologies for design and evaluation of user environments for computer supported interaction and collaboration as well as team work and knowledge transfer'. Special focus is on knowledge management support, (interactive) story telling, human computer interaction, contextual design, and usability engineering.

We have since the start of the education 1999 recognised the crucial lack of focus on user environment, UE, design in relation to technical system design. We therefore in the Multimedia and Knowledge Management course focus on methods for user needs and requirements capture as well as evaluation and usability engineering techniques involving integration of UE and technical system designers.

MASTER IN INDUSTRIAL IT, MII, OPEN EDUCATION

The MII education (Christiansson, 2004a) 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 'Development of Internet-applications' and the second year theme 'Development and use of industrial IT systems'. The students follow 5 tracks of specializations,

- IT in Construction.
- IT in Distributed Real-time Systems.
- IT in Industrial Production.
- IT in Process control.
- IT in System Administration.

Subjects covered are software development in praxis (Java, databases), usability engineering and system evaluation, system modelling, intelligent systems, control and management, administrative it-systems, systems for knowledge management and collaboration, multimedia and interactive systems, human computer interaction, and embedded systems. The specialisation is realized through tailored PE courses and project work. See also http://it.bt.aau.dk/it/education/index.html#mii.

EDUCATION RESEARCH CONNECTIONS

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, ICT Support at the Building Site, building model server in praxis, and participation in the ongoing Danish National Digital construction Program (clients' demands on; building modelling and visualisation, facility management/digital delivery, project web support, and meta data classification), see also http://it.civil.auc.dk/it/projects/index.html. Completed research and 30 years experiences within the field is of course naturally incorporated in the courses.

CONCLUSIONS

The paper presents structures of the learning domains of building informatics exemplified with experiences from building management civil engineering and open education in Industrial IT at Aalborg University. The learning domains as defined in the paper must be in force to raise competence among civil engineers who also to a great extent will be responsible for the (creative) design of future industry ICT implementations, that will support

communication, collaboration, knowledge transfer, as well as distributed building process information and model handling. There is a lack of dedicated learning material and it is therefore important that involved groups make course material available on the web for experience exchange and solid build up of the building informatics science domain.

Industry collaboration on both student and teacher levels are crucial for timely coordination of the ongoing technological, organisational, and work content change process. The Aalborg PPBL, Project Organized Problem Based Learning, methodology has shown it's value in these respect.

Students must not only acquire knowledge on how to use existing ICT tools but gain deep insights in ICT tools used to support and build tomorrows building process support systems such as semantic web and meta data based handling of distributed information containers, and building process models. At the same time teacher competences must be upgraded for efficient use of ICT tools for group and individual tutoring as well as operative knowledge on ICT supported working methods and learning material production and use in virtual learning spaces.

REFERENCES

Berners-Lee T, Hendler J, Lassila O. (2001). "The Semantic Web. A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities". *Scientific American*, May 2001.

Christiansson P (2004a) "Life long learning for improved product and process modeling support". *Proceedings of the 5th European Conference on Product and Process Modelling in the Building and Construction Industry - ECPPM2004*. 8-10 September 2004, Istanbul, Turkey. (eds. Attila Dikbas & Raimar scherer). A.A. Balkema Publishers. Leiden ISBN 04 1535 938 4. (pp. 667-673). http://it.bt.aau.dk/it/reports/ecppm2004.pdf

Christiansson P (2004b) "ICT supported learning prospects" (editorial)*, ITcon Vol. 9, Special Issue ICT Supported Learning in Architecture and Civil Engineering (Per Christiansson editor)* , pg. 175-194. ISSN 1400-6529. http://www.itcon.org/

Christiansson, P. (2003). "Next Generation Knowledge Management Systems for the Construction Industry". *CIB W78 Proceedings 'Construction IT Bridging the Distance", ISBN 0-908689-71-3. CIB Publication 284*. Auckland, New Zealand. (pp. 80-87).

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

Kjærsdam, 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 R. J. Sternberg and and L. F. Zhang (Eds.), Perspectives on cognitive learning, and thinking styles* .Case Western Reserve University (40 pp) http://www.learningfromexperience.com/ELt_review_paper.pdf

LOM (2004) "Learning Object Metadata/Standard for Information Technology -- Education and Training Systems --Learning Objects". http://ltsc.ieee.org/wg12/.