WEB-BASED WATER-RELATED EDUCATION AND TRAINING

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Summary

Water resource management in the natural environment is an important basis of modern human life, driven amongst other topics by the technical progress. The Internet and the World Wide Web are changing our society nowadays in a revolutionary way. This has to be reflected in water-related education and training. This contribution focuses on Web technology for water-related education and training and on related Web-based collaborative engineering. Web-based documents combine traditional text/graphic oriented documents and linked multi-media components into a new kind of teaching

material. Multi-media presentation such as interactive time-depending 3D worlds increases the level of comprehensibility of natural processes. Interactive software components such as Java-Applets expand lecture notes into exercise tools. The hyper-link structure of Web-based documents enables individual reading and study. Web-based documents are platform independent and can be offered time and location independence in the World Wide Web. Document management systems enable a virtual repository/library of teaching material. All these features support self-study as well as Open Distance Learning offers. Information exchange and information sharing in networks over distance and time shift open a new dimension of collaboration by distributed information and documentation systems as well as Web-based project platforms. New working methods such as Web-based collaborative engineering have to be introduced in practice and as prerequisites in education and training. New organizational structures such as virtual classrooms and virtual universities will support education and training over distance and open a new dimension of continuing education for practitioners. These technological innovations require a change in the way of thinking and working as well as in the habits of involved humans. The benefit of Web technology can only be realized by the development of a corresponding Technical Culture - a challenge for education and training.

1. Introduction

1.1. Web Technology and Water-Related Education and Training

Water is an essential pre-requisite of human life, a non-increasable natural resource and central part of the natural processes on the earth. There is no human life without water. Therefore civil and environmental engineering deals, among other things, with water-related, artificial, built infrastructures in the natural environment. This technical infrastructure has to be planned, designed, analyzed, constructed, managed and operated under ecological and economical conditions, defined by the society and ruled by the natural environment. Typical water-related infrastructures are irrigation, drainage and sewer systems, river management and coastal engineering constructions including flood protection, harbors and navigation channels, hydropower stations as well as groundwater management facilities for drinking water supply, buildings sites, waste tips and mining areas.

Education and training in engineering deal with the transfer of state of the art by scientists and experienced practitioners to younger students and practitioners. The state of the art is specified by knowledge and experience, described by information presented in documents of built projects. This includes facts, assumptions, assessments, methods, techniques and rules. Therefore, the core topic of education and training is the information presentation and explanation in related documents and lectures to disseminate knowledge as well as the performance of exercises in typical engineering tasks to develop experience, skills and abilities.

The Internet and the World Wide Web make possible a new evolutionary step in our Information and Communication Technology (ICT) determined world. The Internet as a worldwide network offers new opportunities to disseminate, exchange, store and share information. The World Wide Web as multi-media distributed information system

provides a new level of platform offering location- and time-independent information presentation and access. Everybody can access any information at any place and as much as he likes from any location at any time -- the problem, however, is to find and select the right information. Everybody can communicate via the net with everybody at any time and from any location -- the problem, however, is to find the right communication tools and ways, suitable for the partners involved and the relevant topics. This technical progress influences nearly all areas of human life. Society is changing into an "Information, Communication and Service Society". The benefits of the technological progress can only be realized by the development of a corresponding "Technical Culture" in society -- a process which needs time to develop corresponding working methods and to gain experience in the application of the Web technology by education, training and application.

Academic education in water-related disciplines taught before 1985 is no longer sufficient to operate and compete on a global market and in the technological environment of high tech countries. This demand life-long, continuing, education and training to introduce and apply modern ICT application in practice. Technological progress and the changing society have to be reflected in water-related disciplines by new research, education and training topics:

- Web technology for water-related software systems;
- Web technology for education and training;
- Web-based collaborative engineering.

Details on Web technologies for water-related software systems, such as numerical simulation systems, geographical information systems and information/data mining/analysis, can be found in related journals such as Journal of Hydroinformatics. This article focuses on Web technology for education and training and on Web-based collaborative engineering. Both aspects will be discussed from a technical point of view as well as the related necessary changes in the organizational structure of educational institutions and the evolution of a new “Technical Culture”.

1.2. Basic Features of Web Technology

Nowadays the World Wide Web is changing ICT application in education and practice. Important basic features of Web technology are:

- distributed information system;
- multi-media objects;
- interactive platform independent software components;
- hyper-media documents.

The World Wide Web is a distributed information system: All resources (information, documentation, computational software) are stored and managed on the net by servers within the net. The days of single computer oriented services are gone:

“‘The Network is the Computer’ means all the systems work together like one big resource” -- Scott G. McNealy, President of SUN Microsystems, April 1987. (Really, 1987 !!)

Using this philosophy all necessary resources are provided on the net. The operation system is the Internet; the user interface is the World Wide Web with the Web browser as front end. All information and resources are provided by Web servers and transferred as platform independent objects. Objects contain data, actions and methods. Even XML can be used to add semantic descriptions to objects (self-describing objects) to identify contained information. The user can download all necessary information from the net and can provide new information on the net. He can use resources over the net such as high computer performance, data storage systems and document archives. “Information Exchange” is being extended towards “Information Sharing”. This new aspect of net application will introduce tremendous innovations in water-related education and training as well as in practice.

The World Wide Web opens a new dimension of multi-media information presentation. Originally types of multi-media objects were textual and graphical objects, structured and laid out in documents as HTML pages. Today multi-media objects (e.g. audio, video or 3D worlds) enable an efficient presentation of time-dependent processes in three-dimensional space. Extensions of Web browsers provide interactive handling and control functionality. Interactive platform independent software components (e.g. Java applets) are coming up in Web applications for pre- and post-processing. The object-oriented approach supercedes the traditional approach to separate complex programs and function libraries, large databases and complex textual and graphical documents, and integrates them into a more flexible combination of net-based software modules. Web-based documents integrate these features in a non-sequential structure. In this way they expand the traditional paper-based documentation into interactive hyper-media documents.

1.3. Innovation by Web Technology in Water-related Disciplines

The described basic features of web technology lead to new innovative applications in water-related disciplines:

- Web-based simulation systems
- Web-based monitoring and control systems
- Web-based collaborative engineering
- Web-based project platforms

Simulation systems are used to simulate and analyze the relevant processes of water-related infrastructure and the corresponding natural environment. They are mainly based on databases for input and result data (data management), pre- and post processing components (data analysis), simulation components (processor, numerical engine) and interfaces for visualization, presentation and documentation tools. Simulation systems today are designed for single computers and are based on separated data structures and algorithms. Web technology will introduce new software systems based on the object-oriented approach combining data and algorithms in coherent units designed for application in a net-based distributed environment. New license models (e.g. network license to rent software) will support new types of business models and new ways of collaboration on the Internet.

Water resource management such as drinking water supply, irrigation, drainage and

hydropower operation, and flood prevention, as well as harbor, river and waterway management, demands an effective monitoring and control system. These systems collect, analyze, and present on-line information from different sources (measurements, simulation systems, observation) and include control modules for artificial built infrastructure and communication systems for traffic messages. Web technology in combination with mobile IC-Technology (such as UMTS) enables new opportunities to standardize and integrate different modules towards a flexible monitoring and control platform, accessible from different locations and for different operators.

Projects including civil, environmental and hydroengineering tasks are mostly characterized by their interdisciplinarity and heterogeneity. This fact is intensified by the globalization of society in all fields and by the increasing importance of ecological, legal, financial, social and global economical aspects. Today complex engineering projects are performed in a closed cooperation of partners at different locations with time shift working periods, from different disciplines and educational background as well as with different nationalities, mentalities and working methods. Education and training have to reflect these changes in engineering by new topics such as “Web-based Collaborative Engineering”. Web-based collaborative engineering in complex engineering projects demands Web-based project platforms to share project information and to collaborate in a common “virtual” space, the Extranet.

2. Historical Evolution of Computer-based Education in Hydroscience

Historically, the computer was first developed and applied to computation in civil engineering. The computer operated in its original form on sequential organized algorithms based on simple mathematical operations and data. It is an ideal instrument for schematized and iterative calculations on vectors and matrices. Numerical methods were developed to substitute continuous differential equations by discrete representations (e.g. Finite Element and Finite Difference Method). Sufficient small discretizations allow the solution of differential equations, which formerly had demanded experimental or field investigations. Computers in their first days and up to the 70s were only accessible as “mainframes” in computer centers of big institutions because of high investment and maintenance. For these reasons numerical simulation applications developed slowly. Computer simulation was a domain of universities and research centers. In the following decade equally powerful computers became available to smaller research and business units. This allowed the spread of numerical simulation in education, application oriented research projects and practice. Today these tools are standard instruments in all hydroengineering projects. This first evolutionary step was reflected in the introduction of

- numerical schemes, and
- sequential programming (algorithm)

in standard course programs in water-related curricula such as hydroengineering. Several water-related simulation software systems (such as HEC, Mike, TELEMAC) have their roots in academic research and education at this time.

Since 1980, workstations and personal computers appeared on the working desks of scientists and engineers. These computers offer integrated functionality for

computation, data storing and management, graphical presentation, visualization and documentation. Data storing enables computer-oriented management and analysis of mass data from measurement as well as from numerical simulation. Graphical presentation and visualization were very important to promote numerical modeling. Results were no longer numbers. Colored pictures convinced practitioners of the value of numerical simulations. Documentation systems enabled new kinds of reports and drawings. This evolutionary step was reflected in the introduction of

- graphical/geometric algorithms,
- data base management and data analysis methods, and
- presentation/visualization techniques and methods

in the standard course programs in hydroengineering curricula. Information modeling and related theoretical basis such as set theory became an important part of ICT-based engineering. The term "Hydroinformatics" was introduced and related new course programs were offered (such as IHE Delft, The Netherlands http://www.ihe.nl).

First use of computer connection by networks in the mid-80s was dominated by file transfer for data exchange. One example is the pre- and post-processing at the user's local workstation and the remote simulation/analysis processing on a high performance computer. At the beginning of the 90s operation systems and user interfaces were offered as graphical window-based systems supporting network application by client/server technology. Office packages integrated typical documentation tasks such as text processing, image processing, table calculation and simple data base handling. CAD and GIS software enabled map and drawing oriented design and documentation. In this traditional way of computer and network applications all necessary resources, shared programs and data were operating on just one computer. This could be a PC or workstation on the desk or alternatively on a remote server. The net is used to transfer resources over the net and to realize a remote control by events. Education and training was extended by the introduction of

- application of office packages,
- application of GIS and CAD software, and
- software interfacing and integration

in water-related course programs. Unfortunately this was sometimes combined with a reduction of theoretical (mathematical and physical) insight. A new step in this evolution has come about with the Internet since 1990. The network component was added to the existing multi-functionalities of computers. Much effort has been spent to customize the advantages of graphical window-based user interfaces, object-oriented languages as well as net capacities and functionalities. Increasing Web technology and platform independent, object-oriented techniques are now opening new dimensions for information modeling, knowledge management, and decision support as well as new ways of collaboration in engineering. This evolution step of network application led to the introduction of

- network application,
- object-oriented information modeling,
- distributed software systems and information basis, and

- net-based project platforms and collaborative engineering

background in water-related education and training offers. In addition, a new opportunity for education and training has arisen over the last years: Web-based courses as open distance learning opportunities based on interactive multi-media education material and remote supervision. This leads to new structures in education such as virtual universities and related degrees. This last evolutionary step in ICT is still an on-going process. Technological aspects as well as the social-economical impacts of modern collaborative engineering at “any time - any place” have to be considered in water-related education and training.

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Bibliography

ETNET 21 - Thematic Network for Education and Training in the EC Homepage: http://etnet.vub.ac.be/etnet21.asp [This is an example of a thematic network to integrate education and research in the environment water field.]

IAHR European Engineering Graduate School Environment Water Homepage: http://www.uni-stuttgart.de/IAHR/home.html [This is an example of an international organization providing a common course program. The course program includes short courses, summer schools and Internet-based courses.]

Molkenthin, Holz, Price, Jozsa HydroWeb – Web-based Collaborative Engineering in Hydroscience Homepage: http://www.hydro-web.org [This is an example of an international course on Web-based Collaborative Engineering in Hydroscience. The course runs as an ODL course on the Internet as co-operation of several universities.]

Biographical Sketches

Klaus-Peter Holz studied civil and structural engineering at the University of Hannover. He got his diploma in 1965 and his degree of Dr.-Ing. in 1969. He worked in the software industry for two years and returned to the University of Hannover to continue research work on numerical and informatics methods applied to water and coastal engineering. In 1978 he became a lecturer and since 1982 Professor at the University of Hannover. In 1994 he moved to the University of Technology at Cottbus. He heads the Institute for “Bauinformatik”. Research of this institute concerns numerical and informatics methods applied to all field of civil engineering as well as Web-based collaborative engineering. He is leader of several national, and a member in various European, research projects related to the development of “Hydroinformatics”.

Frank Molkenthin studied civil and structural engineering at the Berlin University of Technology and got his Diploma in 1988 and his degree of Dr.-Ing. in 1994. He moved to the Brandenburg University of Technology at Cottbus and focused his work on the application of Web technology in “Hydroinformatics”. He is involved in several European research and education projects dealing with “Web based Hydroinformatics Systems”. Since 1998 he has provided summer schools and Internet-based courses in “Hydroinformatics”- related topics as part of European and international networks of universities and institutions.