European Joint Program in Construction IT – Early Experiences

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ABSTRACT: In autumn 2001 nine universities started a project with the aim to develop an interuniversity postgraduate program in Construction IT. The program will be offered to students on most of the partner universities, and on some of them it should start already in the academic year 2003/2004. The students will 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 program has been developed with the purpose that students will not only get the best subjects, but will also get the very important experience of other universities and cultures, and of using IT in the learning and working process.

Some partner universities, like University of Salford, already got experiences in distant learning. To extend them and to try more, mostly videoconferencing technologies, TU Dresden and University of Maribor joint two classes of students in the early 2003 and run a 30 hour seminar on “Mobile Computing in Construction.” Valuable observations have been taken, which were then used to design an ideal distant learning environment. 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 Virtual University in Construction IT.

1 INTRODUCTION

Researchers in the field of civil engineering were often in the frontlines in using new technologies while solving their specific problems.

Many reasons were found which make the application of information technology in the construction industry more challenging: uniqueness of products, dispersion of production, diversity and a great number of companies included in the building life cycle, etc. Many authors have analysed these particularities and have tried to lay guidelines for more efficient development and use of construction information technology (Björk 1999, Turk 2000).

It has been often noted that the uptake of information technology in the construction industry has been slow, slower than in other industries. Researchers still seem to live under the impression that they have all these fantastic solutions and that all that is lacking is a way to make the construction industry use them. Several research projects have tackled this issue from the perspective of educating the practitioners and tried to bring research results closer to the practice (e.g. SCENIC 2002) or asking the practice what it actually wants (ELSEWISE 2002).

We believe that a part of the reason also lies in the current education practice. After all, graduated students are powerful agents of change in construction companies, and a powerful technology transfer mechanism. During undergraduate studies, subjects are typically available that introduce computer science, elementary programming, office and CAAD software. The students are supposed to master skills so that they can use computers in the assignments given in the professional, engineering courses. During these courses they also learn about particular software that tackles that particular area, for example finite elements solvers, planning and scheduling software, proportioning and reinforcement design programs etc.

This is exactly where the problem lies; (1) none of the above actually fits the definition of construction IT, (2) such a way of learning about discrete, unconnected software tools only widens the "sea" between the "islands of automation" and (3) does not educate in an area where the potential of IT in construction is the largest - in integrating the fragmented profession and thus providing a holistic perspective. These problems are address in a proposed Erasmus project “European Master Program in Construction IT” and elaborated in this paper.

At present the share of IT subjects in undergraduate civil engineering curricula varies considerably from university to university. Typically there are general introductory courses and specialised courses on IT applications like design of building models, technical drawings, finite element and heat loss programs
for the determination of physical behaviour, systems for construction management, or systems for enterprise resource planning. The courses are mostly civil engineering oriented and are therefore lacking consistency from the aspect of informatics or information technology. Graduates, coming to the construction industry, only know how to use the existing information systems, but have no idea of the many hidden potentials of today’s IT. To improve this situation, some civil engineering faculties enriched their curricula by advanced IT (and ITC) courses, typically database systems, visual programming and component technology, Internet technologies, product and process modelling, or general information system development.

To reform undergraduate curriculum is, however, not an easy task. The question of how much IT a civil engineer needs has very many different answers. Therefore an IT focused postgraduate course seems to be an easier way of upgrading the knowledge of civil engineers with the necessary IT understanding.

Since adequate human resources and experiences in Construction IT are scarce it has been proposed to join forces and develop an international multi-institutional postgraduate program (ITC Euromaster 2002).

The main objectives of the project: to accelerate the transfer of latest (Construction) IT into practice, but also accelerate the research and development in the field; to further develop the Construction IT network and enable better cooperation between participating institutions. Furthermore, construction business is getting extensively internationally oriented and strongly linked with the developing e-business, requiring engineers who are well prepared for these purposes. Therefore the development of ITC education must be seen as an integral part of e-Europe.

But there are also negative effects of the dispersed students and teacher’s situation, which requires effective solutions for overcoming the distance problem. The solution, again, is in using IT to support multimedia distant communication. The issue of developing a distance learning environment is the main topic of this paper.

2 EUROPEAN MASTER PROGRAM IN CONSTRUCTION IT

Discussion in Reykjavik in 1999 resulted in a project proposal, which has been submitted to the Socrates Erasmus call in 2000 (Erasmus 2002). The proposal has been accepted and in autumn 2001 the project started for the duration of two years.

The main purpose of the project is to develop a curriculum on ITC to give students the possibility to extend their knowledge in the application of computer science in civil and building engineering. The result, a European Masters curriculum in Construction IT, should complement the existing portfolio of teaching programs and meet the growing demand for such skills. In the case of those institutions already offering ITC courses, the project will provide the added value of a European dimension for their existing ITC program. The following universities joined the project consortium (in alphabetical order):

1. Universidade do Algarve, School of Technology
2. Technische Universiteit Delft, Subfaculteit Civiele Techniek, Afd. Bouwtechniek & Bouwprocessen
3. Technische Universität Dresden, Fakultät Bauingenieurwesen
4. Universidade nova de Lisboa
5. Univerza v Ljubljani, Fakulteta za gradbeništvo in geodezijo
6. Univerza v Mariboru, Fakulteta za gradbeništvo (coordinator)
7. Háskóli Íslands, Reykjavik
8. University of Salford, School of Construction & Property Management
9. Bauhaus-Universität Weimar, Faculty of Civil Engineering
10. University of the West of England, Bristol

The partner institutions are among the leading ones in the ITC field. The IT Institute at the University of Salford is offering a MSc/Ph.D. Construction IT distance learning course, TU Delft is currently offering a PhD program in Construction Informatics, which includes Product Data Technology, Knowledge Technology, Communication Technology and Construction Robotics.

The coordinating institution, the Faculty of Civil Engineering at the University of Maribor, is developing ITC related subjects since 1979. A special effort has been focused on continuous improvement of subjects and their systematic integration in undergraduate as well as postgraduate programs. The faculty is also participating in related projects, with which results will be mutually enriched: a Tempus program “Open and distance learning in technical education” (Tibaut, 2000a), and “The Student’s Computer”, which is also expected to positively influence the IT share in education. Its goal is to equip every student with a mobile computer, and to adequately adopt the lecture rooms and the courses (Tibaut, 2000b).

Based on an early draft of the curriculum and on the results of a skill audit and review of existing
courses at partner institutions, as well as market research and analysis, a course structure has been set consisting of 12 subjects (Table 1).

<table>
<thead>
<tr>
<th>Subject</th>
<th>Coordinator</th>
<th>Partners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role of IT in construction</td>
<td>Ljubljana</td>
<td>Bristol, Dresden</td>
</tr>
<tr>
<td>Databases and data structuring</td>
<td>Maniobor</td>
<td>Dresden, Dresden</td>
</tr>
<tr>
<td>Information modelling and retrieval</td>
<td>Lisboa</td>
<td>Delft, Dresden,</td>
</tr>
<tr>
<td>Software engineering</td>
<td>Dresden</td>
<td>Ljubljana, Dresden</td>
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<tr>
<td>Modelling and visualisation</td>
<td>Delft</td>
<td>Dresden, Maniobor</td>
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<td>Knowledge Management</td>
<td>Delft</td>
<td>Dresden, Ljubljana</td>
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<tr>
<td>Knowledge Based Systems</td>
<td>Algarve</td>
<td>Dresden, Lisboa,</td>
</tr>
<tr>
<td>Communication / Web</td>
<td>Bristol</td>
<td>Ljubljana, Dresden</td>
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<td>Mobile Computing</td>
<td>Maniobor</td>
<td>Dresden</td>
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<td>Virtual Enterprises</td>
<td>Lisboa</td>
<td>Algarve, Dresden,</td>
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<tr>
<td>Computer Integrated Construction</td>
<td>Bristol</td>
<td>Dresden, Ljubljana</td>
</tr>
<tr>
<td>eBusiness and eCommerce</td>
<td>Dresden</td>
<td>Delft, Lisbon</td>
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Table 1. ITC Euromaster curriculum and the responsible partner institutions.

To each subject a responsible partner has been assigned who is coordinating the development of the content and of the teaching material. Teaching materials will be prepared in conventional as well as in an ODL form.

The curriculum will be offered either as a new studying program or included in relevant existing programs, depending on the partner’s current situation and higher education system. On most partner institutions a new postgraduate program on Construction Information Technology will be offered, giving a “European Master on Construction Information Technology” as the postgraduate academic degree, which will enable students either to continue the studies as PhD students or to work in the industries as civil engineers with a specific focus on Information Technology. It is planned to start the courses in the academic year 2003/2004.

The curriculum is focused on students who have finished their undergraduate studies with a university degree in civil, building or structural engineering. A roughly estimated average of 10 students per participating country per year would give about 50 students in the first year. It is, however, expected, that the number will increase in the following years. The civil and building industry with related areas will need more engineers with profound IT understanding and knowledge in the e-society of tomorrow.

The outcomes of the project are also most important for the competitive position of the building industry, which urgently needs a better IT support, for which it mostly needs highly educated people with relevant knowledge and understanding. Offering courses in the proposed distributed way will give the students the best existing knowledge and quality in the ITC field, enriched with the European dimension. It is expected that the effects of the project will influence the development of the whole construction industry.

2.1 Cooperation instead of competition

The main idea of the common course development has been to share and to jointly further develop the knowledge in the ITC area. During the preparation phase of the project, a skill audit has been conducted to establish the existing expertise available at all participating universities in ITC areas. Each partner has also carried out a market survey in its country to identify the knowledge and skills required by the building and civil engineering industries. This helped the project partners to decide the scope of course curriculum. At the end of this phase a course document was completed covering course structure, course contents, delivery methods, assessment methods, marketing and recruitment strategies, and plan of the operation of the course delivery.

The second phase of the project is to develop the course contents. The curriculum is being developed in such a way that courses will be offered from several universities in conventional as well as open and distance learning (ODL) form. In this way the courses will give the best quality that partners can offer regarding their staff, experiences, materials and equipment. Each partner institution will contribute different numbers of subjects to the joint program depending on the matching between the curriculum topics and the existing expertise of each institution as revealed in the first phase (see table 1).

The courses once developed will be taught through a combination of face-to-face teaching and Internet based distance learning teaching methods. Students will register with each individual institution and study the taught units offered at their own institution through the well-established mode of delivery prevailing at the institution. In addition, the students will study taught units offered by other partnering institutions through Internet based distance learning complemented by lectures delivered by visiting academics. In this way the accessibility of courses will be maximized. Students will also have opportunities to visit other universities during their study. This will provide them with a flexible and interesting learning experience, as well as getting more familiar with engineering methods, technologies and culture of specific countries.
The distance learning delivery system will be based on the model pioneered at the University of Salford in its Internet distance learning courses (Salford 1999). The distance learning arrangement will enable the partnering European universities to share teaching and learning resources and provide their students with a high quality European wide ITC curriculum.

After the project is finished we expect to start the programs in the academic year 2003/2004. Each partner will be responsible for seeking approval at its own university to run the joint Masters in Construction IT course. At most partner institutions a new postgraduate ITC program will be introduced. An international steering committee will assure continuous running and improvement of the curriculum and related programs, as well as adequate continuous marketing and recruitment.

During the development of the curriculum a strong network of partner institutions has formed, which enables a smoother flow of knowledge and experience in the ITC field between partners, but also broader. The list of interested parties, which has been set up in Reykjavik (CIB W78 2000), also includes institutions from USA (Stanford University), Canada (University of British Columbia) and Australia (University of Technology Sidney). At the 1st international ITC in Education workshop in Portorož in September 2002, which was strongly influenced by the ITC Euromaster project, the ITC@EDU Network has been founded at the panel discussion to support and link together teachers in the area of Informatics and IT in Construction (ITC@EDU 2002). Therefore the significance of the project exceeds the curriculum development alone, as it has become the linking point for the further development of ITC education globally.

3 DISTANCE LEARNING EXPERIMENT

The main parts of our joint teaching experiment were commonly held lectures transmitted by videoconferencing tools.

The lecture series consisted of single lectures that are already part of the individual curricula of either University of Maribor or Dresden University of Technology. The lecture content was modified in moderate way; however it had to be translated into the English language in order to allow for bi-lingual teaching mode (English / German). The goal was to improve the teaching and learning methods and skills with a special focus on ODL-technologies.

3.1 Content, and Course of Events

As mentioned, we combined five modules each running over 6 academic hours. The following modules were taught:

- Introduction to Mobile Computing
- Business Process Modelling
- Information and Data Management
- Communication and Agent Technology
- Best Practices for Mobile Computing

The ODL-scenario allowed the integration of guest-lecturers from Carnegie Mellon University to present their experiences and research results within the last module and thus enhance the scope of the lecture series to an international level.

The teaching material was presented to the students by using shared applications. In most of the cases Powerpoint slides were presented using the application sharing mode of “NetMeeting”. After the lectures the teaching material was additionally made available to the students through the existing web-based platforms of each partner university. Using separate platforms allowed for individual schedules and additional seminars taught individually.

3.2 Technical Infrastructure

We used two layers of interaction to connect the lecturer’s and class rooms as depicted in figure 1. The “Video & Audio Layer” supported the communication between the distributed locations. A multi-point conferencing unit was provided by the University of Maribor. According to older experiences (Menzel, Ilal, Harttkopf 1998) the performance of the TCP/IP-backbone has been improved since that time. Within our experiment, it was possible to establish audio/video communication between the facilities of the participating universities with sufficient quality by using the internet.

![Course Infrastructure Diagram](image)

Figure 1: Course Infrastructure

Unfortunately our students reported about different quality levels when connecting from their homes to the MCU in Maribor by using analogue or ISDN-modem connections.
The “Data-Sharing Layer” supported the concurrent usage of applications. Different types of supporting infrastructure were used during the joint teaching experiment.

3.2.1 Local Infrastructure at Univ. of Maribor
At University of Maribor a completely equipped CSCW-Lab was used. Besides the two video cameras a sophisticated audio system with wireless microphones etc. is available. Additionally the Lab is equipped with W-LAN access points. This would theoretically allow the students to access the broadcasted teaching material with their own laptop computers.

3.2.2 Local Infrastructure at Dresden University
At Dresden University flexible, mobile hardware configuration was tested, consisting of two laptop computers and two beamers. One machine was used to work as the videoconferencing unit. This laptop was additionally equipped with a microphone as well as external loudspeakers.

Using a second machine allowed for establishing a second internet connection and using this machine to present/receive the shared teaching material.

3.3 Infrastructure: Lessons Learned
Today’s available integrated IT-infrastructure allows it to students to passively attend lectures from everywhere. Active integration of students needs a backbone supporting sufficient performance for bidirectional audio and video transmission. One might argue, that video connection is not always necessary. However, students requested for video-communication in individual interviews avoiding “anonymity” of the lecturer.

Furthermore interactive work is an essential part of seminars. In that case, application sharing might help to develop ODL-scenarios. Interactive cooperation is more than using some software or documents together.

We argue, that the ICT-infrastructure does not sufficiently support all modes of interactive, remote seminars. Personal contact with lecturers or teaching assistance will still be necessary for individual guidance and support.

3.3.1 Video Quality
Both technical set-ups supported a good quality for teaching scenarios, the CSCW-Lab in Maribor and the flexible environment at Dresden University. The limitations of the flexible teaching environment were achieved in discussions, when the lecturers initiated spontaneous discussions between students. Remote camera control and stored positions are very helpful features to allow lecturers to focus on the individual and her/his specific contribution.

Video Quality is strongly related with the lighting equipment. The CSCW-Lab in Maribor was much easier to control than a traditional class-room at Dresden University. Automatic blind control and multiple artificial lighting scenarios ensured an optimal scenario. The standard lighting devices without dimming features and low-quality blinds at Dresden University contributed to less video quality.

3.3.2 Audio Quality
Audio quality is strongly impacted from the quality of the microphones used. Furthermore, the available audio equipment influences strongly the possible modes for presenting the teaching material to the students.

On the one hand head-sets help to suppress echo by using this specific type of hardware. As long as the local students do not need to listen to comments from remote audience this solution might work. On the other hand, it also leads to the psychological effect that the lecturer is “encapsulated” into the “technical” equipment and thus loosing the contact to the students sitting in the class-room.

3.3.3 Wireless Devices
The usage of wireless headsets, connected by blue-tooth adapters, delivers the following advantages. Firstly, the microphone is attached to the lecturer in a “static” way and can thus be tuned once and used over the whole lecture time. Secondly the lecturer can act “hands-free” and is thus able to better interact with local students. Finally, the lecturer can present the teaching material by using a smart board and explain digital content in a much more interactive way than sitting “static” behind her/his PC or laptop computer.

3.3.4 Tablet PCs
The touch screen of tablet PC’s can be used as an alternative solution to smartboards. Teaching material can be annotated by the lecturer in an easy way by using the pen working on the touch screen.

The combination of animated slides and annotation will lead to more interactive teaching scenarios, avoiding the “sterility” that is inherent by presenting complete slides.

Tablet PC’s might be used either in big lecture halls, where the size of smartboards is to small for presentation or in rooms without smartboard.

4 HANDS-ON EXPERIENCE NEEDED
The authors claim that there is no “ideal” ODL-environment. Besides purchasing and installing sophisticated information and communication technology in the class room it needs additionally practical experience in using such equipment. Lecturers need to learn how to interact with remote audience by
“evading” technical limitations and complementary usage of technical advantages.

Last but not least each lecturer herself/himself must develop “trust” into the technical environment and a certain level of practice in dealing with all components of such environments.

The authors suggest to start working with simple but robust technical environments. These environments can be incrementally improved. This approach helps to understand the complexity of such systems and to learn about the interrelations among the single components.

However, one should never forget that the pure availability of technical equipment does not automatically improve the quality of teaching. The methods of teaching need to be modified or extended according to the specific capabilities of the integrated technical system.

5 CONCLUSION

The international teaching effort described in this paper provided an excellent opportunity for the involved instructors and student team members to be exposed to the challenges of interdisciplinary, multicultural team work. The exchange program was a perfect testbed to observe how to organize and apply available communication technologies efficiently.

Bringing together the best we can offer in teaching is a positive effect if we can deliver this knowledge to everybody who is seeking for it. To organise the knowledge in the field of information technology in construction is the main objective of the ITC Euromaster project, but to develop an effective environment to support the classes with distributed teachers and students bears at least the same importance for the success of the developed studying programs.

In the paper we have shown that there is still a lack of effective modular, integrated ODL environments required for supporting distributed classes, but we have also shown on our own example that the demand for such environments is growing fast. Such environments will become the basis for a borderless, virtual university, linking together teachers and students of multiple countries, nations or even continents.

It is our belief that interdisciplinary, multi-national teaching efforts will positively affect the way students perform certain highly specialized tasks. An improved understanding of the interdisciplinary impacts among the various A/E/C-disciplines, as well as among the A/E/C and computing technologies will result from such efforts.

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