ANOTHER STEP TOWARDS A VIRTUAL UNIVERSITY IN CONSTRUCTION IT

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SUMMARY: *Nine universities started a project in autumn 2001 with the aim to develop an interuniversity postgraduate program in Construction Information Technology. The program is intended to be offered to students on most of the partner universities. 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 the partner universities can offer in this specific area, but will also get the very important experience of other universities, countries and cultures, as well as of using IT in the learning and working process. Some partner universities, like University of Salford, already offer programmes in open distant learning mode. To extend the experiences 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 conceptualize 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 future Virtual University in Construction IT..*

KEYWORDS: *IT in education, virtual classroom, virtual university, ODL, ITC Euromaster, Socrates Erasmus.*

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 exist which make the application of information technology (IT) in construction industry exceptionally challenging: uniqueness of products, dispersion of production, diversity and a great number of companies included in the building life cycle, to name just the most important ones. 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 those 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 an important part of the reason for not using IT in construction effectively 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 CAD 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.

And this is exactly where the problem lies; (1) none of the above actually fits any definition of Construction IT (ITC), which are as a rule more holistic oriented ("Construction information technology is equipment, applications, and services that are used by organisations to assist human communication, commitment negotiation, problem solving and decision making, and spans over several civil engineering disciplines.", Turk 2000) (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 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 are to accelerate the transfer of latest (Construction) IT into practice, but also accelerate the research and development in the field; to further develop the ITC 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, but also to organise courses and classes in a virtual environment of the Internet - in a Virtual University. A Virtual University in Construction IT could be seen as a final goal of our efforts

2. EUROPEAN MASTER PROGRAM IN CONSTRUCTION IT

A discussion about the problems and potentials of ITC in education among participants of the CIB W78 conference in Reykjavik in 1999 (CIB W78 2000) resulted in a proposal of a postgraduate programme development project, 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 Construction IT to give students the possibility to extend their knowledge in research, development, and application of computer and information 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

The partner institutions are among the leading ones in the ITC field. The IT Institute at the University of Salford is offering an MSc/Ph.D Construction IT distance learning course (Salford 1999), 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 developed consisting of 12 subjects (Table 1).

TABLE 1. ITC Euromaster curriculum and the responsible partner institutions (the list of partners changed a little during the project).

String	Subject	Coordinator	lectures / tutorial / individual	ECTS credit points
Introduction	The role of construction informatics	Ljubljana	30/30/210	10
Data & Information	Databases and data structuring	Maribor	30/30/210	10
	Information modelling and retrieval	Lisbona	30/30/210	10
	Modelling and visualisation	Delft	30/30/210	10
	Software engineering	Dresden	30/30/210	10
Knowledge	Knowledge management	Delft	30/30/210	10
	Engineering Artificial Intelligence	Algarve	30/30/210	10
Communication	Computer mediated communication	Bristol	30/30/210	10
	Mobile computing	Maribor	30/30/210	10
Business & Management	Computer integrated construction	Bristol	30/30/210	10
	Virtual enterprises	Lisbona	30/30/210	10
	eBusiness	Dresden	30/30/210	10

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.

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 each year. It is, however, expected, that the number will increase after the programme becomes well known in the construction industry and among the students. We are convinced that the civil and building industry will need more engineers with profound IT understanding and knowledge in the e-society of tomorrow. It is expected that the effects of the project will influence the development of the whole construction 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.

3. 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 at all participating universities to establish the relevant existing expertise. Each partner 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 was to develop the course contents. The curriculum has been 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).

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.

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, 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 (Rebolj 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). It becomes evident that the significance of the project exceeds the curriculum development alone, as it has become the linking point for the further development of ITC education.

4. DISTANCE LEARNING EXPERIMENT

One of the immediate positive effects of the project was a much deeper and continuous cooperation between the partners. In this regard many ideas arose, which were compatible with the goals of the project. One of them was a joint teaching experiment were commonly held lectures were exchanged between Dresden University of Technology and University of Maribor by using videoconferencing technology. The experimental course consisted of single lectures that are already part of existing subjects. The content was modified in only moderate

way; however it had to be translated into English in order to allow students from both universities to understand the lectures. The main goal of the experiment was to improve the teaching and learning methods and skills with a special focus on ODL-technologies.

We have combined the following five modules, each running over 6 academic hours:

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

In the final module guest-lecturers from Carnegie Mellon University were invited to present their experiences and research results and thus enhance the scope of the lecture series to a global level. The teaching material was presented to the class by sharing a common presentation application. The 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.

We used two communication layers between lecturers and classes as depicted in Fig. 1. The “Video & Audio Layer” supported the visual and vocal communication between the distributed locations. A software based multi-point conferencing unit was provided by the University of Maribor. According to older experiences (Menzel et. al. 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. Some students, who have connected to the MCU from their homes by using analogue or ISDN-modem connections, reported about different quality levels. The “Data-Sharing Layer” supported concurrent use of teaching material. Most often Powerpoint presentations were shared with the support of NetMeeting software.

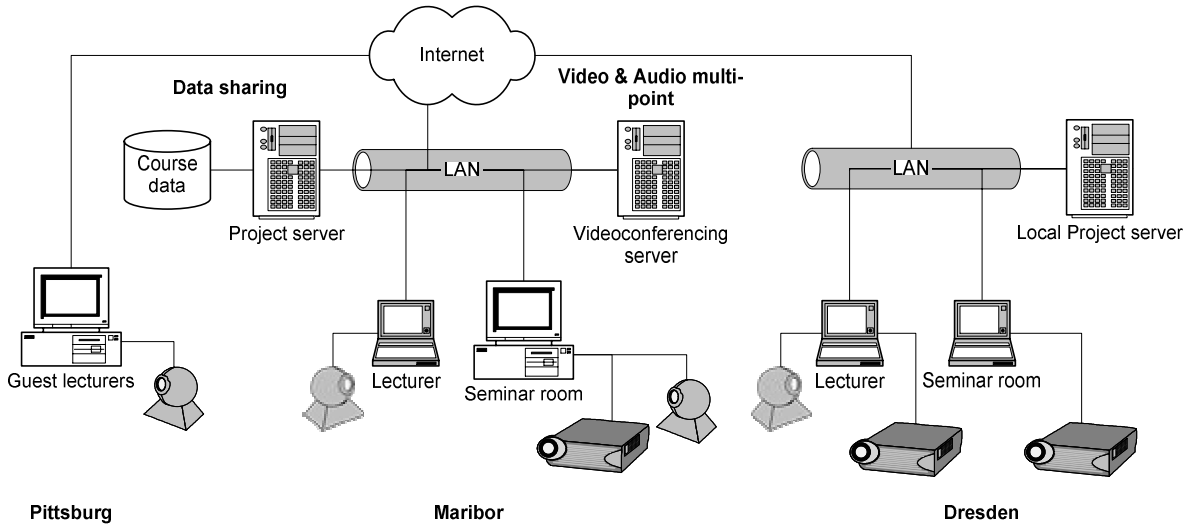

FIG. 1: Course Infrastructure

Different software (CUSeeme videoconferencing server, VCON MXM server, CUSeeme client, vPoint, client and NetMeeting) and different types of supporting infrastructure were used during the experiment. At University of Maribor a completely equipped CSCW-Lab, including two video cameras and a sophisticated audio system with wireless microphones was available. Additionally the Lab is covered with LAN and W-LAN access points, which allows students to access the broadcasted teaching material with their own laptop computers in a variety of ways.

At Dresden University flexible, mobile hardware configuration was tested, consisting of two laptop computers and two data projectors. One laptop was used as the videoconferencing unit. It has been additionally equipped with a microphone as well as external loudspeakers. Using a second machine allowed for establishing a second internet connection for application sharing for presentation of teaching material.

Today's available integrated IT-infrastructure allows students to attend lectures from everywhere passively. Active participation of students require a backbone with sufficient performance for bi-directional audio and video transmission. One might argue, that video connection is not essential. However, according to individual interviews students requested for video-communication for avoiding "anonymity" of the lecturer. Furthermore interaction is an essential part of seminars. Application sharing, including the share of control would help to develop ODL-scenarios. But interactive cooperation is more than using some software or documents together. We argue that the IT infrastructure does not (yet) sufficiently support all modes of interactive, remote seminars. Personal contact with lecturers or teaching assistance will still be necessary for individual guidance and support.

Both technical setups 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, when lecturers initiated spontaneous discussions between students. Remote camera control and stored positions are very helpful features to allow lecturers to focus on an individual and her or his specific contribution. Video quality is also strongly related with the lighting equipment. The CSCW-Lab in Maribor was much easier to control than a traditional classroom at Dresden University. Automatic blind control and multiple artificial lighting scenarios ensured an optimal scene. The standard lighting devices without dimming features and low-quality blinds at Dresden University contributed to less video quality.

Audio quality is even more important and is strongly impacted from the quality of the microphones used. Furthermore, available audio equipment influences the possible modes for presenting the teaching material to the students. A headset seems to be a good solution, since it suppresses echo, but 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 classroom. Desktop microphones are less disturbing, but since they are more sensitive, they transmit too much noise and echo the voice from the loudspeakers. Wireless clip microphones have proven to be most useful. The microphone is attached to the lecturer in a "static" way and can thus be tuned once and used over the whole lecture time. Also 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 computer. Bluetooth headsets, connected to computers by Bluetooth adapters, seem to be a good standard solution for the future.

The touch screen of a tablet PC can be used as an alternative solution to smartboards. Teaching material can be annotated by the lecturer in an easy way by using 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 PCs might be used either in big lecture halls, where the size of smartboards is too small for presentation or in rooms without a smartboard.

5. TOWARDS A VIRTUAL UNIVERSITY IN CONSTRUCTION IT

Although the authors claim that there is no ideal ODL-environment, the efforts are focused on a concept of an environment for optimal support of distributed learning. "At the dawn of 21st century, distributed learning appears to be an indispensable solution to the exponential growth of information in the knowledge society and the new learning activities it forces on individual and organisation" (Paquette 2002). To successfully run the interuniversity ITC Euromaster programme a distributed learning environment is the only solution.

Since resources are scarce and the output is expected to be accepted gradually by the construction industry, we do not intend to start with a fully developed virtual learning centre, with an ODL environment comparable to the United Kingdom's Open University (The Open University 2003) or alike. Instead our intention is a »bottom-up« approach through which we will optimally build the teaching and learning environment and the organisation of the programme. On the other hand ITC Euromaster is, due to its interuniversity structure, an ideal candidate that can evolve into a virtual university in Construction IT.

According to our experiences a firm technical infrastructure is a vital part of any virtual learning system. Therefore we will focus on the technical concepts of an ideal ODL environment to support the teaching and learning process. Except at the seminar, we have gathered some further experiences in various other projects, where audio or videoconferencing (HorizonLive, VCON, CUSeeme) and different web based content delivery systems have been used (Blackboard, FGweb). Our experiences, enriched with those of many researchers in the field of using IT for education (Adelsberger, Collis and Pawlowski 2002), led to ideas of an ideal environment to effectively support open distance teaching and learning.

Most often the ODL environment consists of two main components: a Learning management system and a Virtual classroom. The main function of the first is to enable access to teaching and learning material from any location in the Internet. Additionally it can help the institution to organise courses, it can support teachers in preparing, structuring, and storing teaching materials, but also to organise and run classes, and it can enable students to communicate with their teachers and classmates, and to collaborate on common projects. Virtual classrooms are mainly based on conferencing systems (either audio or audio & video) and enable teachers to directly communicate with their classes. A participant list, chat, audio control, and a whiteboard are the basic parts of a virtual classroom. Video, application sharing, a common calendar and other components can enrich the communication.

Many commercial applications exist that cover parts of the needed functionality. Educational institutions, which have organised ODL courses, are combining them to cover their needs. In the same way the IT Institute at the University of Salford, one of the ITC Euromaster partners, is using Blackboard as a Learning management system and HorizonLive as a virtual classroom. Explor@ is a more complex system, developed by the LICEF Research Center of the Télé-université du Québec (Paquette 2002), which is capable to integrate documents and services to support a virtual campus. The authors are, however, not aware of any commercially available modular system that would fully support a virtual learning centre.

This fact, but also the extremely fast development of software for synchronous collaboration support, and the maturity of the software component technology, strengthened our conviction to design a system that would allow gradual development, first covering ITC Euromaster course, and later evolving into a “virtual university campus”.

The conceptual schema is based on the following main requirements:

- programme, teacher, student and subject related teaching and learning content storing and delivery
- class related point-to-point and multi-point audio& video communication
- class related instant messaging

The relevant entities are depicted on Fig. 2 and the main functions shown in Table 2.

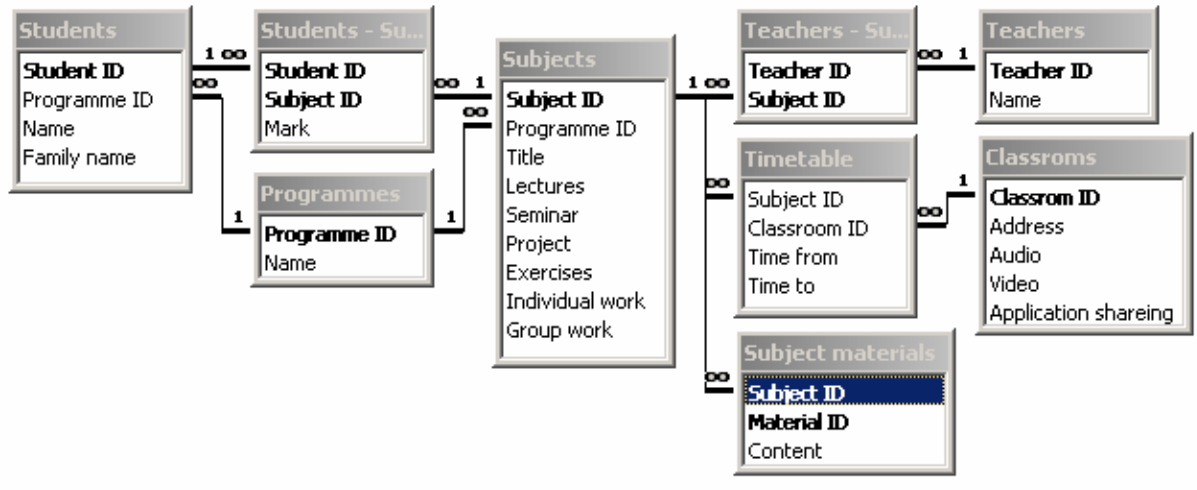

FIG. 2: Relationships of the main entities of a Virtual Learning Centre.

TABLE 2: Communication modes between actors (active entities).

		Communication	
Initiator	Respondent	mode	function
Teacher	Student	Interactive	chat, audio, video, app. sharing
Teacher	Class (Students)	Interactive	chat, audio, video, app. sharing
Teacher	Subject	RWED	text, graphics, animation

Student	Teacher	Interactive	chat, audio, video, app. sharing
Student	Class (Students)	Interactive	chat, audio, video, app. sharing
Student	Subject	RE	text, graphics, animation

The most important required characteristics of the system are scalability, modularity and interoperability. Wherever possible, standard software components or interoperable software modules will be used. The system should not exceed an easy manageable level of complexity and should not become huge or monolithic. Modularity should be kept at the user interface level as well. The following example shows a prototype of a virtual classroom user interface (Fig. 3), consisting of:

- instant messaging system, which becomes a picture of the class by applying certain selection criteria based on context parameters like programme, subject, date and time
- teaching material management, presentation and sharing
- videoconference system, which serves for vocal and visual communication between teachers and students

Only the necessary information is shown on the user interface: the list of relevant students (including their status and optionally voice and video), teachers (voice and video), subject (relevant teaching material). Each participant is able to shape her or his arrangement of information on the screen.

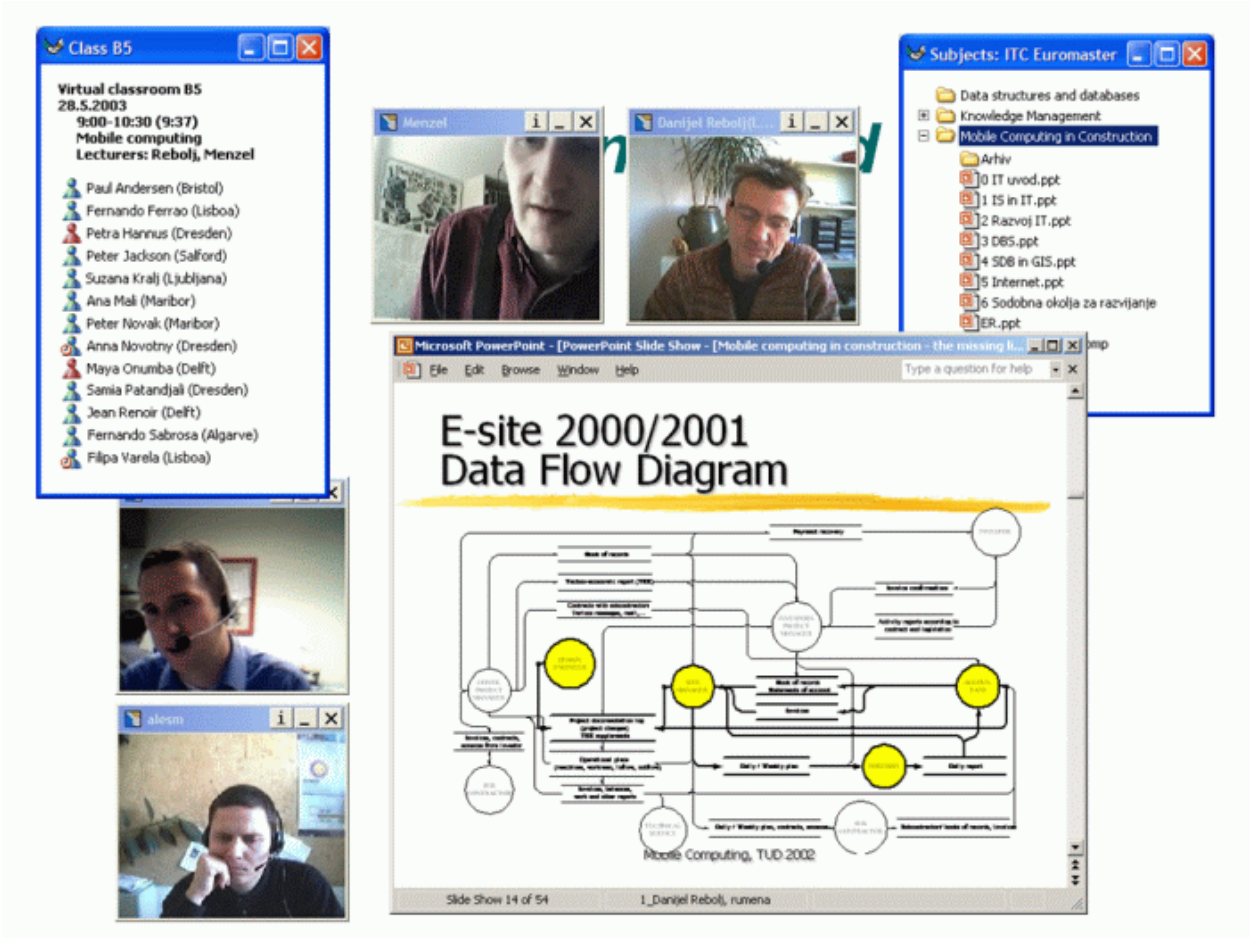

FIG. 3: A virtual classroom.

Of course the technical infrastructure is only one of the many dimensions of a virtual university. Organising virtual courses, managing classes, managing the virtual institution in general, are certainly exacting tasks, which we expect to master through the ITC Euromaster programme. On the other hand certain training is needed for lecturers. Lecturers need to learn how to interact with remote audience by “evading” technical limitations and

complementary usage of technical advantages. Each lecturer must develop “trust” into the technical environment and a certain level of practice in dealing with all components of such environments. 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.

The organisation of a virtual course and class, university and campus, is another exacting and important task. In our case we are in a special situation because the ITC Euromaster programme is a multi-university project. Students will enroll in each university, but they will enter a single virtual class, with teachers coming from all partner universities (see Fig. 4).

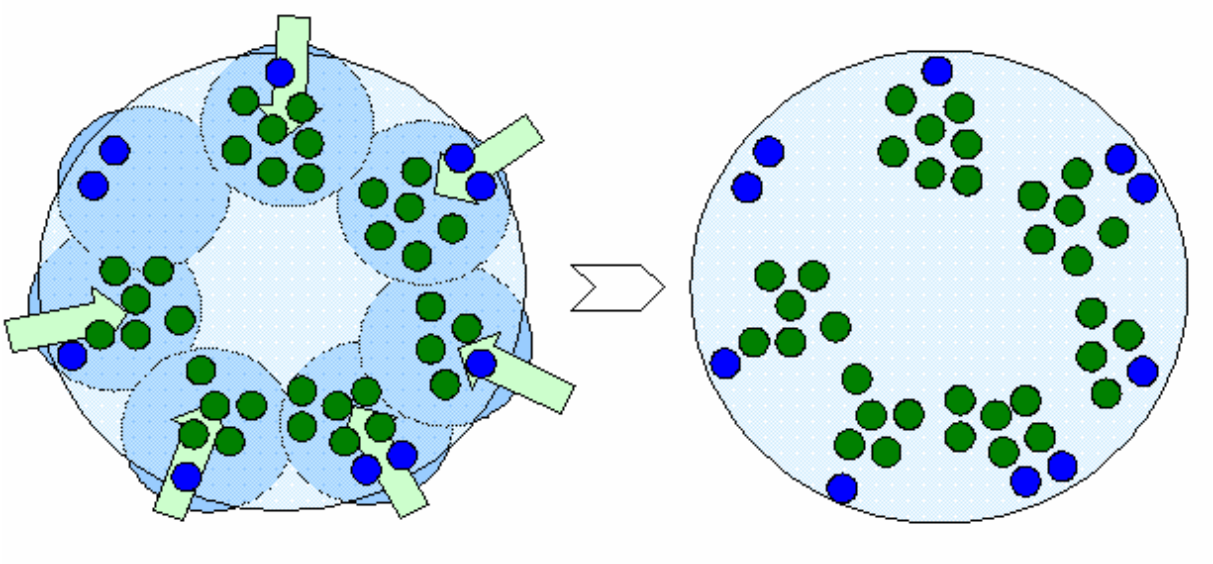

FIG. 4: Transformation of a multiple input - multiple class into a single virtual class (small circles represent students and teachers, middle circles represent partner universities, and the big circles represent the common programme and the virtual class).

For the future we intend to preserve the multi-university configuration. Therefore the virtual university can specialise on Construction IT. This seems to be a paradox, since specialisation and universality are in contradiction. However, universality does exist in the wide resources of the partners. We think that through such approach we can develop a high quality and effective virtual university specialised in Construction Information Technology.

6. 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 test bed 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 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 programmes.

In the paper we have shown that there is still a lack of effective modular, integrated ODL environments required to support distributed classes, but we have also shown on our own example that the demand and the opportunity 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. The only requirement for the student of tomorrow should be curiosity and the will to learn. Nothing else.

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