ICT-SUPPORTED, INTERDISCIPLINARY PROJECT ENVIRONMENTS IN AEC-EDUCATION FOR INTERNATIONALLY COMPOSED TEAMS

Manfred Breit[1], Fritz Häubi[2], Christoph Holliger[3] and Daniel Kündig[4]

ABSTRACT

In Europe the real estate industry currently undergoes a dramatic change process in most countries. From a former regionally organized branch of domestic economy acting in mostly confined markets an internationally operating industry is currently emerging. International competitiveness on the investors' side and performance competition of the AEC industry are increasingly dominating the line of business. In this environment, new processes and organizations with partly virtual collaboration gain in importance. In order to prepare students for these challenges, the "Project Oriented Learning Environment" (POLE) has been created as a novel curriculum project at the University of Applied Sciences Northwestern Switzerland and an international network of collaborating universities has been established. This paper will present the concept of POLE as well as findings and experiences of the simultaneous projects with students working in multi-disciplinary and locally distributed teams.

KEY WORDS

Multi-Disciplinary Teamwork; Distributed Teams; ICT Supported Education, Virtual Project Organization, Decision Making, Computer Supported Collaborative Work

POLE METHODOLOGY

University students are nowadays increasingly challenged within their specific core disciplines. In addition however, they are also supposed to develop skills in order to apply this

[1] Professor, Dr. Ing. Civil Engrg. and AEC related CS. Institute of 4D Technologies and Data Spaces, University of Applied Sciences Northwestern Switzerland, Klosterzelgstrasse 2, Windisch, CH-5210, Switzerland, Phone +41 79 204 63 46, FAX +41 56 462 44 82, manfred.breit@fhnw.ch

[2] Professor, Dipl. Arch. ETH et exec. MBA HSG, Institute of 4D Technologies and Data Spaces, University of Applied Sciences Northwestern Switzerland, Klosterzelgstrasse 2, Windisch, CH-5210, Switzerland, Phone +41 56 462 40 11, FAX +41 56 462 44 82, fritz.haeubi@fhnw.ch

[3] Professor, Dr. Physics. Project Oriented Learning Environment (POLE) University of Applied Sciences Northwestern Switzerland, Klosterzelgstrasse 2, Windisch, CH-5210, Switzerland, Phone +41 56 462 44 06, FAX +41 56 462 44 15, christoph.holliger@fhnw.ch

[4] Professor, Dipl. Arch. ETH, president Swiss Society of Engineers and Architects (SIA), Project Oriented Learning Environment (POLE) University of Applied Sciences Northwestern Switzerland, Klosterzelgstrasse 2, Windisch, CH-5210, Switzerland, Phone +41 44 254 53 53, FAX +41 44 254 53 54, daniel.kuendig@fhnw.ch

particular knowledge in practice. This ideally goes hand in hand with a sense of maturity of the individuals' character vis-à-vis the social, cultural, and economical environment. The practical application of theoretical knowledge can thus only be implemented successfully if these three basic elements are taken into account.

Figure 1: POLE Team concept for the "*Vertical Classroom Project*"

In addition to university students' disciplinary knowledge, the ability to work efficiently within multicultural environments has become increasingly important. This has led to a more proactive stance by universities with regards to networking and offering joint courses, which is where POLE Europe, i.e. Project Oriented Learning Environment, is actively involved in. An example for this is the liaising between strongly research-oriented and more practice-oriented universities with the common goal of being able to implement results effectively and time-specifically. In this process, the POLE Europe course puts emphasis on improved cultural know-how, which is reflected in the international composition of the POLE Europe teams. POLE Europe sees itself as a learning system cooperating with foreign universities. This results in the creation of new solutions regarding teaching and learning methods. The students are at the core of this concept, and are given the opportunity to develop process-oriented expert knowledge through interdisciplinary teamwork. Simultaneously, they learn how to work independently and deal with current problem cases through the use of modern information and communication tools.

Professionals from relevant industries form an essential part of POLE Europe. Their participation contributes a high degree of practical knowledge, linking professional practice and academic education. This exchange allows for a rapid transfer of knowledge and technology and acts as a motivating factor for the participating students. In remolding the landscape of university teaching and learning POLE Europe also intends to provide an impact concerning decision making and creation of practical work processes. In association with university teaching staff, industry mentors are therefore instrumental in contributing expert knowledge and regular feed-backs to the teams. Through collaboration in interdisciplinary teams guided

by process management students (see figure 1), students from various fields of expertise are given the opportunity to understand the individual processes involved and acknowledge their relation to the social, economical, and political dimensions.

ORGANISATION OF THE COURSES

A POLE course starts with a kick-off week where all students come together in Switzerland. They get a thorough introduction into the program assignment, visit the site and meet main stakeholders and join introductory courses dealing with the main aspects of the assignment such as architecture and engineering of high-rise buildings etc. and hands on sessions on the POLE information and collaboration technology (ICT). After that, the team building process takes place. The new teams define their set of goals for the project and plan the necessary processes. At the end of the week, a review with faculty, mentors and owner representatives gives all teams the opportunity to present their work and discuss the proceeding.

The intensive work and the process of becoming acquainted with each other is very important for the following phase of distributed team work, where the students co-operate from their home universities via the internet-based ICT. At two cyber reviews, the teams present their current state of work and discuss with faculty, mentors and the owner representatives how to proceed. At the end of a POLE Europe course all students meet again in Switzerland for the final presentation and the assessment of their work by an international jury. Additional presentations may be organized for investors or other groups of stakeholders. As part of the requirements of the assignment, students have to create a project web page, which shows the objective, the possible and chosen solutions in an interlinked fashion. This enables the user of the page to learn about the interdisciplinary decision processes of the team.

An international jury composed of one representative per discipline, and two representatives from the POLE Europe faculty, assess the performance and teamwork and provides a written statement. The home universities are exclusively responsible for the grading of performances of their students and the awarding of ECTS credit points.

POLE ICT

Pole participants choose their courses primarily because of the challenging topics of the assignment. They are not *technology-driven*, but very interested about the support modern ICT will provide to enhance their work. This shifts the focus to the question, how do processes have to change to make new ICT a success and what changes need to be done with the ICT to support new promising processes. As part of the POLE concept, we use currently available software applications.

Pole participants collaborate over the Internet. Per requirement, students form foreign universities need 24 hours per day access to the Internet with a connection of at least 256 kBits/s and suitable IT support for set up and security issues (firewall settings). A speaker phone with unlimited international access for conference calls is also necessary. To simplify the access to the POLE ICT environment, all information spaces can be reached via the POLE webpage. The POLE webpage is public and offers information about the current courses, has an archive of past courses and forks to team web pages and to the POLE portal, which is only accessible by participants. The POLE portal is the main information server and

built up with the following applications: Lotus Quickplace, Mail and Notes. The Portal is a shared information space and meeting place for all POLE participants.

The portal has the following features:

- News: serves as a bulletin board
- Document server: storing and retrieving documents and shared computer models
- Tasks: a Gantt chart like tool for team process planning and assigning of tasks
- Team Mailbox: a place to store mail, which is important to the team
- Discussion forum

To store documents in a discussion-forum-like fashion, has been proved as very useful. Students can respond to submitted proposals and comment on it. The handling of the system is as easy as writing e-mails. The asynchronous working mode is a tough learning process for all participants, because they are not used to provide most of the information electronically and pro active within the team process. Only after a certain project progress, this extra work pays off. Most of the documents are output of computer applications, such as drawings, pictures, portabe documents (pdf), Powerpoint presentations, etc.. Additional we introduce collaboration on shared 3D models. Modeled solutions are explicit. Possible spacial design – engineering conflicts can be detected at an early stage. Thus helping to increase the quality of the work. The databases are stored on the Portal and the version can be denoted as "check out" to show the other participants the status of the work. This mimiks distributed concurrent design and engineering. The 3D models have been organized to discipline specific file sets (a kind of layer structure in Allplan).

Teams meet on a regular basis in Cyberspace to discuss problems or to take decisions. In so-called Sametime Meeting participants can share applications, draw annotations on a whiteboard at the same time or upload presentations for shared redlining.

Review sessions with design teams are especially challenging, because they need visual communication to a very high degree. The currently available communication systems in this respect often hinder their own purpose. We try to cope with these short comings by the following means:

- Multiple IP-based cameras, displayed in SimuView - an propiatary application, which distibutes multiple camera views over the Internet
- Sametime and SMART bridgit application server
- Telephon and video conference system (Polycom)

The iRoom consists of tree rear projected SmartBoards with touch screen. Every SmartBoard is connected to a PC running Windows XP a fourth PC acts as server. The SmartBoards alone work as enhanced blackboard where the advantages of explaining a problem while writing on a blackboard can be combined with computer applications. The iRoom is used for review sessions of the distributed teams and for presentation purposes. Furthermore at the Intstitute of 4D Technologies and Data Spaces we are developing an agenda based meeting system for the iRoom, which is currently in the pre prototype phase and should be used and

tested in further POLE projects. The application is based on Tidebreaks Teamspot Software and will be developed in cooperation with the Center of Integrated Facility Engineering at Stanford University. HP Switzerland supports this work through hard-ware donations.

The initial task of the new build team is to define their goals and to design the necessary processes at the story board. It shows that the work with cardboards, pencil and paper seems to be the right ingredience to foster the team building process. The resulting process plan is a very valuable executive function if it is used as a vivid co-operation document. We use SMART Ideas from SMART Technologies to combine graphical sketches with hyperlinked information.

POLE PROJECT "VERTICAL CLASSROOM"

The “Vertical Classroom Assignment” (Kündig et al 2005) will deal with the development of a university which may be located in one or several multi-storied buildings. The aim is to break out of the traditional plain perception of a university campus, and to design a university site with a novel space arrangement, which allows a re-evaluation of spaces and the links between them. Parallel to this, the requirements of innovative teaching and learning methods, as well as a flexibility for the future development of the university, must be taken into account.

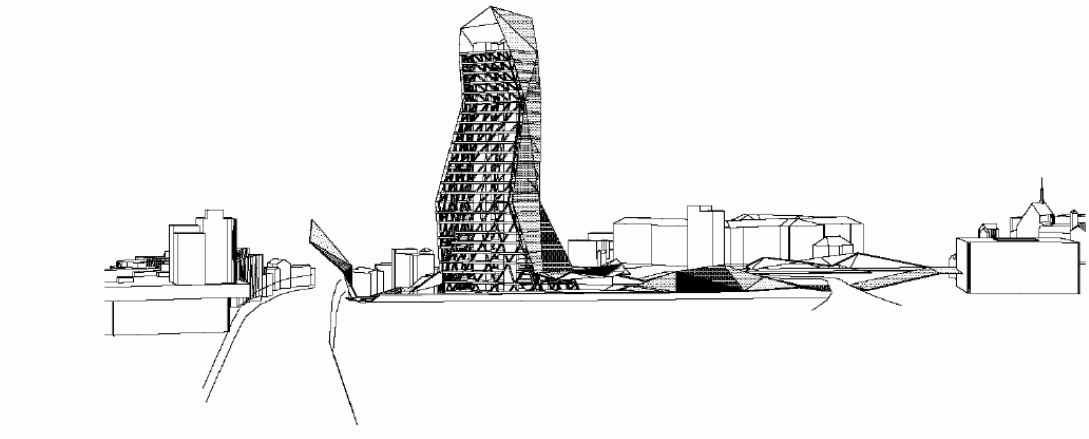

Figure 2: Team Chinook: The university tower as landmark
http://www.pole-europe.ch/chinook/

Deployment of ICT and disciplinary tools

Considering the first POLE Europe courses starting in 2001 up to now, there is a clear tendency to more and systematic team work of the different disciplines. Parallel development can be traced regarding the role of the process managers which have refined and adapted their managing methods due to the experiences of the predecessors. These developments are based on the work of the coaching faculty, who changed their courses and lectures to better prepare their students to the cope with the requirements of interdisciplinary teamwork. The following experiences and findings characterize the interdisciplinary work and the use of modern ICT and disciplinary tools.

- In general civil and structural engineers were not prepared well engough to serve as equal partner for the architect if they come up with challeging architectural shapes and structures. Often their methodolical knowledge is too theoretical and the ability to model the load carrying and deflection behavior is limited. Special input and support from faculty has improved these short comings to a great deal recently.
- Architectural students in POLE projects have only minor experiences with object oriented modeling. Further use of architectural models for the co-operating engineering disciplines is often impossible.
- The collaboration of architects, structural engineers and construction managers has improved significantly during the current POLE project, due to a more precise definition of the duties and objectives of the construction managers. Thus most of the teams provided a 4D animation of the building processes

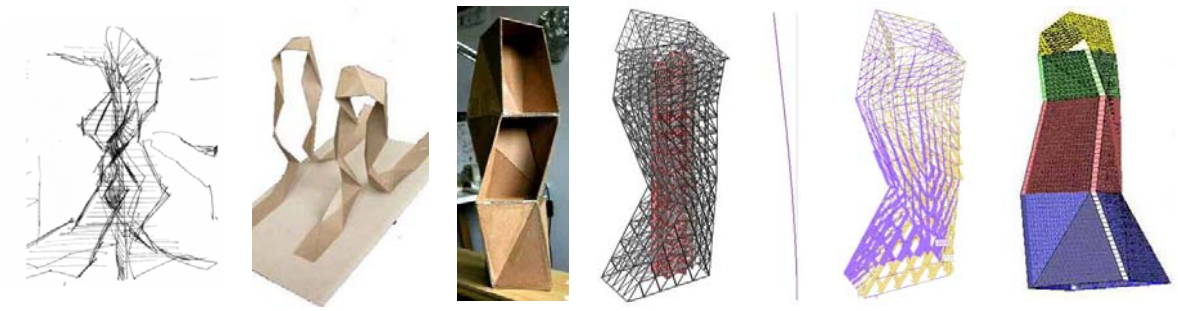

Figure 3: Team Chinook: interdisciplinary development of the project from architecture to structure

FINDINGS OBTAINED REGARDING MANAGEMENT ASPECTS

Within the POLE project managerial functions are executed mainly by process management students. They study in a new curriculum which tries to bridge the gap between the disciplines which is a result of a historical process and the stakeholders involved in the building process. The authors believe that process managers in future will also act as a *project information officers* as proposed by Froese (2005). As part of their work they have to record and to reflect on the experiences in team management. The management coaches alongside observe the leadership behavior of the process manager as well as the team behavior in the project. The findings, described consecutively, are based on an analysis of process reports, protocols and project reviews and are focused on the management effectiveness. Current management theory provides diverse approaches regarding this issue. Malik (2003) names the following executive functions as characteristic for effective management "to set objectives, to organize, to decide, to evaluate results, to encourage humans". In POLE we analyze the managerial performance due to the following criteria:

- achievement of objectives due to given formal criteria

- quality of the results due to the evaluation of the disciplinary experts
- quality of the coordinations work due to the team reports
- quality of the decision making processes in the team due to the notes (diaries) of the process manager
- conditions and comfort of the team members

The current management experiences of distributed interdisciplinary teams in POLE projects which collaborate using Internet-based collaboration tools can be summarized to seven hypotheses:

1) The principal management functions of projects, processed in virtual environments do not differ from those of traditional organizations. They have to be operated more deliberately and the utilized methods need to be adapted to the special work situation.
2) The project start is far more crucial to success as in traditional organizations. The principal team players need to know each other personally and an intensive team and trust building process is necessary. This initial phase can not be substituted by other collaborative actions in Cyberspace at later phases of the project.
3) A necessary precondition for the success of projects is an efficient ICT- environment, which can be managed and is used by all team members. Even sophisticated Internet-based management supporting tools remain ineffective, if principal management rules are not applied.
4) Decision making processes need to be prepared and documented carefully. In distributed teams the synchronous development of solutions in open discussions is only possible to a limited degree and time consuming.
5) ICT environments need a highly structured mode of operation. This may narrow the creativity of individuals. The deployment of the creative potential of the team on the other side is both the most difficult and the most essential managing function.
6) Effective project controlling, especially the systematic preparation, formulation and tracking of decisions contribute essentially to the success of projects.
7) The process management requirements and the skill requirement of the responsible project manager are comparatively higher than in traditional organizations. In addition to sound managing capabilities consolidated knowledge about the potential and the restrictions and experiences in the handling of the ICT tools is necessary.

Process management and control in virtual teams

During the project start, when the teams meet for the first time, the awareness for management aspects and the management efforts increase. The start phase will be recognized as intensive, motivating and interesting but also as conflict-prone and demanding. Team building processes and the analysis of the assignment interfere. In the following we concentrate however on management aspects and the specialties of leading distributed teams.

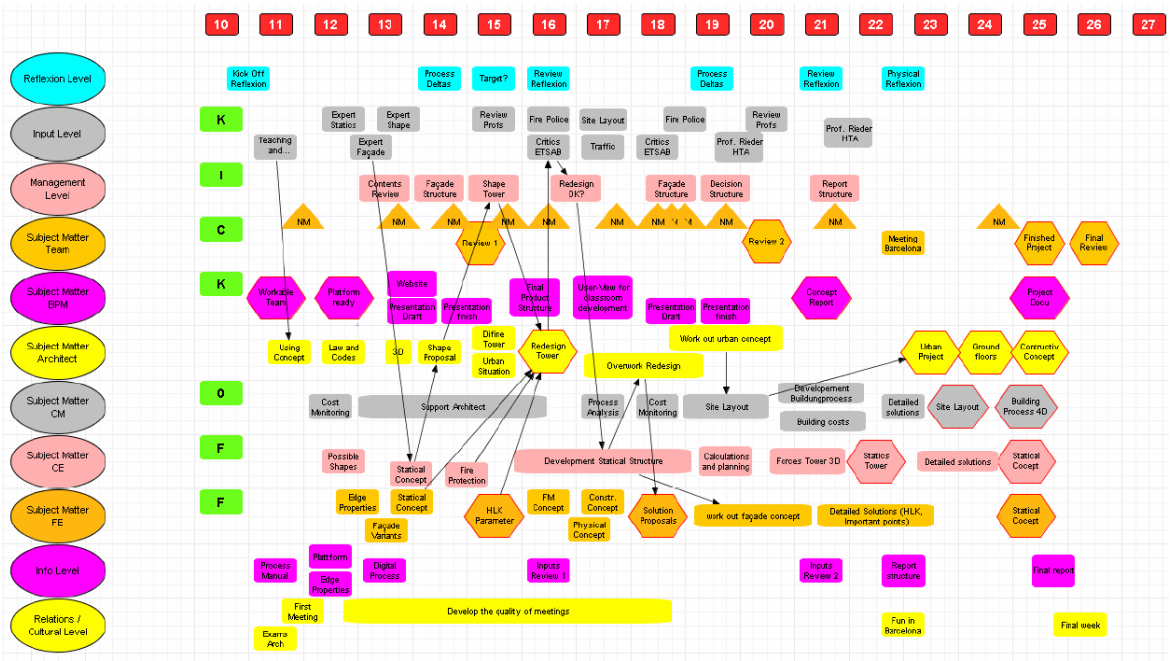

Figure 4: Team Chinook: digital process planning

As expected, the participants recognize the co-ordination of the subject matter and schedule of the team work as predominating management function. To solve these conventional methods and tool for scheduling and resource management will be applied. Beside this, most of the teams regard the definition of the project objectives and its specification as essential but often as single non-iterative action. Project reports show the success of teams who manage to define a continuous process of goal definition and specification over those who concentrate to define detailed definitive goal systems once for the project.

A special challenge of distributed team work is the team- and project-oriented configuration of the ICT environment during project start. Successful teams use multi-dimensional approaches, which allow balancing the aspects of document managements and exchange and synchronous collaboration. Only methods and systems of data management, which are intuitive and easy to understand, survive the project duration without laborious re-design efforts. With regard to the synchronous collaboration it has been proved appropriate to train practically the technique of speech, the data exchange and the report and documentation of results already in the start phase.

Decision making processe in distributed teams

From a management perspective decision making and pursuing the realization of decisions are the core problems in distributed teams. This results mainly due to the physical distance of the team members and has both psychological and technical reasons. Usually relevant decisions will be taken in synchronous online conferences, at which available tools will be used selectively. In terms of psychology, physical distance provides a certain form of non-commitment. The involvement of the participants is limited and often directed to local

problems and relationships. Especially directly after the start phase a significant drop of motivation can be observed. During decision making processes, when it is essential to find creative solution or to find compromises or to react sensibly to the mental state of others, the distance hinders both the spontaneity and the commitment. Even sophisticated video conferencing systems currently offer no satisfying solution of the problem.

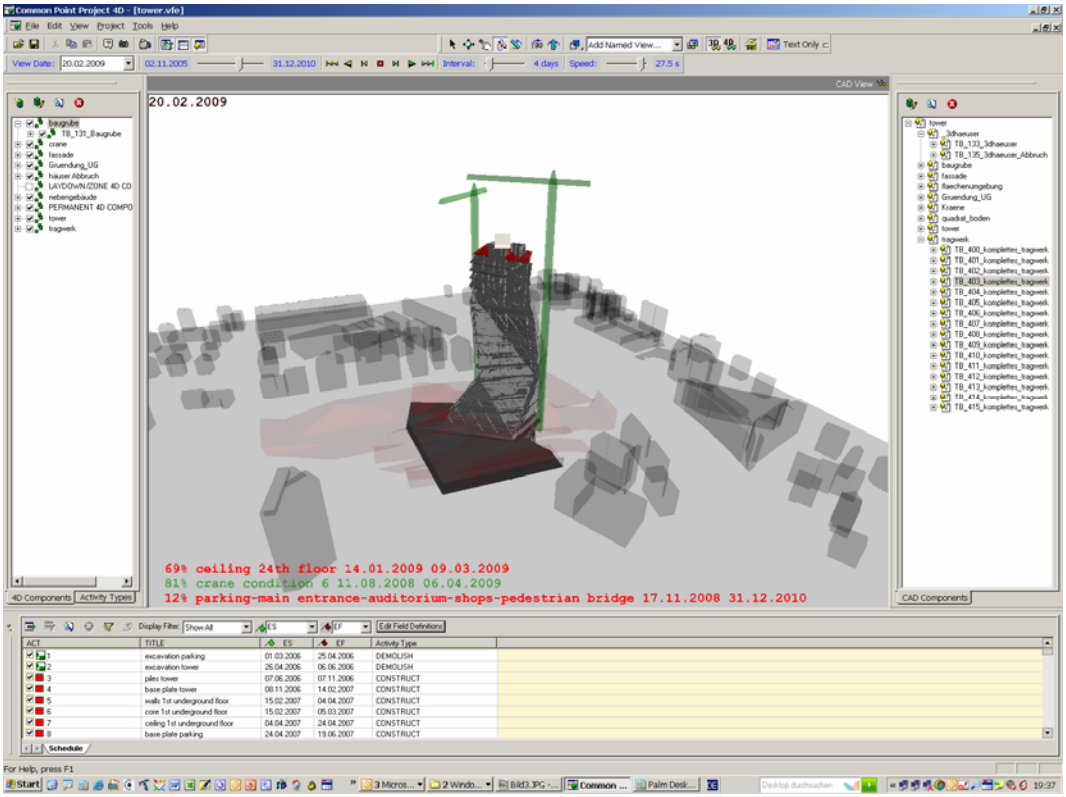

Figure 5: Team Chinook: 4D animation of the building processes

From a management perspective, the problem is based on the relatively high effort to formalize the decision making process and on the restricted influence on the behavior of the participants simultaneously. Most of the process managers prepare the meetings with more or less comprehensive documents for the scheduled decisions, which are distributed prior to the meeting via document server or email. They try to conduct the decisions in simultaneous meetings at which preferably all relevant team members participate. Structured discussions where process managers concentrate on the moderation and determination of achieved results have been proved relatively effective. Typically decision making processes run through the following sequences: vote on open decisions, reconciliation of the decision principles, vote on the applicable decision procedures, clarification of open questions, pursuing the decision and determination of the decision. Essential is a detailed report of the course of the discussion either by means of the automatic protocol features of the ICT system or by protocol of a designated team member. In both cases a post processing by the process manager is necessary.

In the observed projects decision were brought about mainly through consensus. Decisions by a majority and complex decision techniques have been proved as not effective, because full acceptance is regarded as decisive factor for the effectiveness of team decisions.

INTEREST OF THE REAL ESTATE INDUSTRY

As mentioned before the real estate industry in Europe currently undergoes a dramatic change process in most countries. As a consequence new forms of collaboration, partly in virtual organizations gain importance. Against this background leading companies and organizations, investors, owners as well as planner and fabricators participate in POLE projects.

CONCLUSIONS

Our experiences up to this point show that interdisciplinary, simultaneous and distributed project work on challenging and demanding AEC projects can lead to considerably better results through a synthesis of the contributed knowledge from the disciplinary sources involved in comparison to traditional project work.

ACKNOWLEDGMENTS

The POLE project has received financial support from Swiss Virtual Campus, and is currently a development project of the University of Applied Sciences Northwestern Switzerland. POLE has also received donations form industry sponsors. The authors want to express their gratitude and thank for the support.

REFERENCES

Froese, T.M. (2005). "Information Management for Construction" *Proceedings of the 4th International Workshop on Construction Information Technology in Education,* Dresden University of Technology, Germany

Kündig, D. et al (2005). Assignment "Vertical Classroom", University of Applied Sciences Aagrau, available at http://www.pole-project.ch/pole/en.downloads.htm

Kündig D., Häubi, F. and Breit M. (2004). "Project Oriented Learning Environment (POLE)", *Proceedings of the Xth International Conference on Computing in Civil and Building Engineering*, Bauhaus-Universität Weimar, June 2004

Malik F. (2003). "Führen Leisten Leben", *Deutsche Verlagsanstalt Munich,* 2003

Holliger, C. and Breit, M. (2001) *Interkontinal Lernen – Lernen im Bauwesen über POLE (Project Orientes Learning Environment),* tec 21 Heft 38, Schweizer Ingenieur und Architektenverein, Zurich, Switzerland

Fruchter, R. (1999) *Architecture / Engineering / Construction Teamwork: A Collaborative Design and Learning Space.* Journal of Computing in Civil Engineering, Vol 13, No. 4, pp 261 – 270, ACCE, Reston, VA 20191-4400, USA