
LEARNING ABOUT BIM IN EARLY DESIGN USING INPRO TRAINING ENVIRONMENT

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ABSTRACT

The paper presents an approach of dissemination of research results from research project to construction industry praxis. It addresses the problem of insufficient skills that prevent adoption of novel methods of working and technology. Presented work originates from European integrated project InPro, which aim is to develop methods and technologies that facilitate industry changeover to a model based and collaborative way of working especially in early design phase of the construction project. To support project goals and facilitate the industrial transformation and industrial technology take-up, the project implemented tools and developed curricula and materials for training and education of management, architects, engineers, and construction workers, as well as university students. The paper presents training environment developed to support training on model based work practices and enhancement of hands-on skills with regard to model based working focusing on early design processes. Technical solutions, content topics and development experiences are described. Content of training courses and curricula is based on experiences from live project demonstrations and use cases.

Keywords: education, training, business courses, university curricula, model based working

1. INTRODUCTION

The field of construction IT explores vast potential of information technologies for the benefits of construction industry and consequently for the benefits of the end users of construction industry products. One of the main streams of the efforts for many years now is utilization of model based working in all aspects of the construction project. We can recognize these trends in research strategies (Hannus, 2003; Samad, 2007) and many specific research projects that can be followed through construction IT related series of conferences like CIB W78 or ECPPM or other scientific publications. All these efforts generate strong need for IT proficiency of construction professionals and of course also construction competencies of IT professionals. On these foundations, the needs for new professions emerge, like BIM managers, design integration specialists (Tatum, 2009), etc.

A way to bring new discoveries and research results into everyday praxis and to develop new types of experts in the industry is certainly education of practitioners. Such efforts can be recognised in projects back to SCENIC (Hannus, 2007). Fruchter (Fruchter, 1999) reported on combined research and curriculum development for multidisciplinary, geographically distributed architecture / engineering / construction (AEC) teamwork. Other successful attempts were reported from different research networks (e.g. Elspass and Hollinger, 2004). Authors of this paper also contributed to the subject via development and operation of Euromaster program (Rebolj, 2008; ITC Euromaster, 2009), which is the basis for InPro training environment described here. For better understanding of InPro training environment principles and organization, Euromaster background is briefly described in the following chapter.

InPro training environment is a deliverable of InPro project performed under EU 6th framework programme for research and development. The project recognises the importance of dissemination of newly developed knowledge not only via research papers, professional organisations and media but also via formal university

education and life-long education of current and future professionals. To achieve ambitious goal of construction industry transformation, targeted work packages are dedicated to development of training programmes for higher education as well as for professionals at all levels plus extensive dissemination activities. Educational content which is delivered via InPro training environment is direct result of the project research work.

2. INPRO TRAINING PLATFORM BACKGROUND

1.1 Euromaster project

InPro training platform builds on foundations of ICT Euromaster programme (ITC Euromaster, 2009). The programme complement existing university courses because 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, often based on particular software. A European Masters curriculum in ITC complements the existing portfolio of teaching programs. It tries to advance construction IT education, introduce more holistic perspective of IT in construction industry and integrate the fragmented profession.

The accreditation process of a joint study program performed by several universities proved to be a problem, since different rules are in power in such many different countries and universities. To overcome formal obstacles and to open the program to the global community we have decided to form an open pool of ITC related courses. Once the new partner institution is accepted by the steering committee, the institution can include any number of existing courses in its own programs, since the pool is based on reciprocity. Having a whole pool of courses at hand certainly gives each partner a strong background to form a whole new program and to offer their students specialized knowledge and skills which they could possibly never be able to offer by themselves.

1.2 InPro project

InPro (InPro, 2006) is a European cooperation between 19 construction sector companies, IT companies, consultants and research organisations from 8 countries. The project runs from 2006 to 2010. As stated in the project's Description of work:

»The InPro project will completely transform the Early Design phase of a building (new or renovation) project. At this influential phase, which represents only a fraction of the lifecycle of a building, decisions are made that determine over 70% of the total lifecycle costs. The Early Design phase also has a direct impact on the building's added value for all stakeholders, as well as on the construction sector's efficiency and sustainability.«
The project develops strategies and business models for a new building design process which enforce open cooperation between project partners and consider the building's whole lifecycle. New business concepts and processes are defined that provide incentives for model-based working and open collaboration between all stakeholders. From technology point of view, smart, fully semantic ICT platform and tools are developed or specified enabling exchange, sharing and reuse of information throughout the building lifecycle.

The main output of InPro will be the "Open Information Environment" - an advanced system of Early Design processes, supported by radical business concepts and ICT solutions that integrate four crucial and closely interlinked aspects of Early Design: (A) Open and flexible collaboration between all stakeholders of the building value chain, (B) Design from a lifecycle perspective, based on 3-dimensional Building Information Models, (C) Decision support to make "informed choices" based on knowledge of each decision's consequences on the building lifecycle, (D) Early planning of build and operation processes based on computer enabled simulation of smart digital prototypes.

To support this radical change in the industry and to facilitate the industrial transformation, project has strong focus on curricula and materials for training and education of management, architects, engineers, and construction workers, as well as university students. The need for education and further developments is covered both for the initial transformation of the industry, but also for the long term development of architecture and engineering sciences.

1.3 Training strategy

Training strategy used in development of InPro training content is based on InPro project communication strategies that foresee industrial transformation on three levels: project, company and industry level. It also identifies stakeholders involved in this transformation such as policy makers like the European Commission and national governments and standardization bodies, developers of new knowledge such as universities and research institutions and important participants in the early design process such as clients (both public and private), architects and designers, contractors and construction companies.

The training and education strategy for the business pull focuses on the benefits for the main drivers of change in the sector, that is make them aware of the need for change and create desire to support and participate in the change. On the technology push side, the training and education of the organization on processes, methods and tools will transfer the knowledge how to manage model based working methods.

InPro training platform broadens the scope of Euromaster in a sense of target audiences. Beside universities, courses for building industry are developed. On the other hand, InPro learning content is more focused. It covers methods of work and IT tools related only to Early Design processes of construction projects.

3. LEARNING PLATFORM

To support collaboration and implement learning courses on such a broad scale it is inevitable to base learning platform on technically effective e-learning system. The platform should support wide array of teaching, lecturing and collaboration activities and tasks. Our experiences from Euromaster show that technical infrastructure is a vital part of the system.

When designing the system architecture, we set scalability, modularity and interoperability as the most important requirements. The system should consist of well established and open software tools that can be combined into overall system and that can be eventually replaced by competing products without too much effect on other parts of the system.

E-learning platform should be able to support preparation, storage and distribution of learning materials, implementation of self-study courses, online lectures, blended learning, student evaluation and assessment. Course planning and course management, student enrolment and study programme management should be supported as well. Beside traditional teaching activities, collaboration among participants, both student-lecturer and peer to peer are vital, therefore functionality like discussion groups, forums, blogs and wikis are necessary. Since InPro training environment content covers both teaching about new methods of working and learning about software tools that enable new way of working it is necessary to combine hands on learning following constructivist approach, with tutorial and group learning.

From above mentioned requirements, system architecture was developed and is presented in Figure 1. It shows three vital parts of InPro e-learning environment, which are video/web conferencing tool, course and content management system and BIM laboratory. Based on our experiences and market research we decided to implement proposed architecture with open source portal based software tool Moodle - Modular Object-Oriented Dynamic Learning Environment (Moodle, 2009) as the LCMS tool, Adobe Connect Pro (Adobe, 2009) is included as video/web conferencing environment and BIM laboratory is based on Share-A-space BIM collaboration hub developed by Eurostep (Eurostep, 2009).

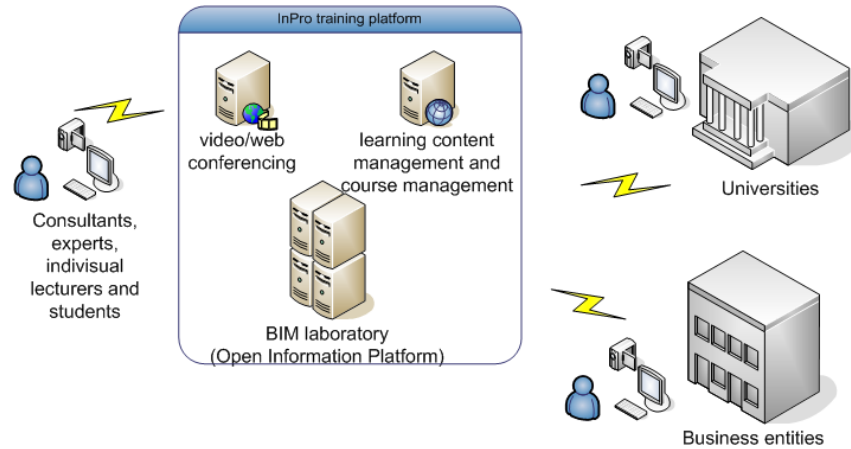


Figure 1. InPro training platform architecture

4. LEARNING CONTENT STRUCTURE

Learning content is developed as a set of learning modules which should cover knowledge necessary to understand and to be able to work in “the InPro way”. The modules are structured in such a way that enables integration of InPro modules into existing and future university curricula. At the same time and to avoid duplicate work, the modules should also fulfil the needs of business courses targeted to industry professionals.

3.1 Structure and use of learning modules

The main source of knowledge for new learning modules is project research work which has been mainly structured around identified early design key processes (KPs) of construction project. Direct focus on KPs is however not suitable for organization of learning modules, because KPs does not provide broader context of concepts of model based working. KPs are very good source of knowledge that has been used in formulation of learning modules, however additional mapping is needed. This additional mapping brings InPro knowledge in context of existing state of the art and practice, which is necessary to make learning modules and new ways of working understandable by the students.

To meet specific needs and different levels of proficiency (existing and needed) the learning modules should be structured in several levels of detail and our proposal is that each module contains three levels of detail, which could be studied in sequence or independently.

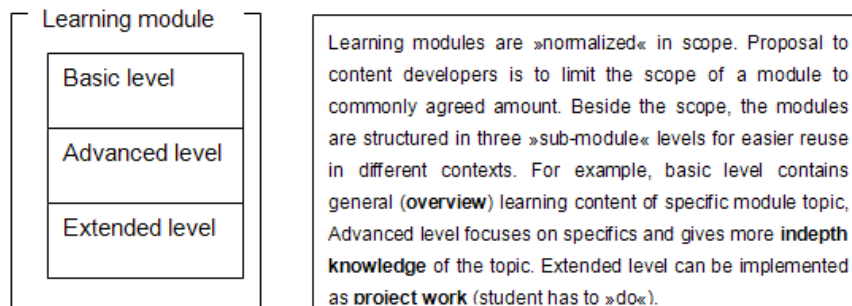


Figure 2. Three level structure of the learning modules

In such a way it is possible to use the same learning modules in variety of contexts. For example a university can integrate two InPro modules into an existing curriculum as described in figure 2.3.

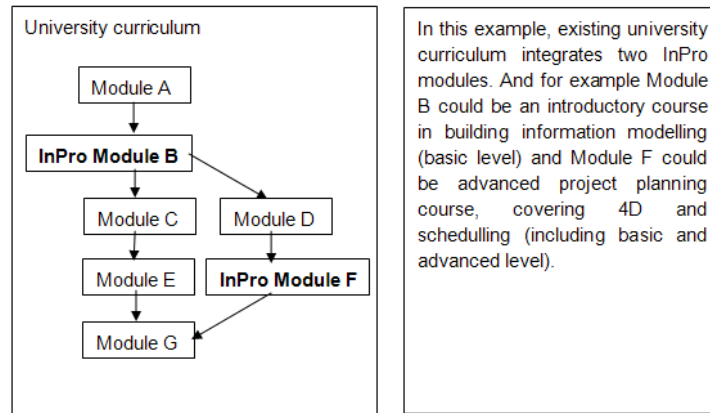


Figure 3. Example of use of InPro learning modules in university curriculum

At the same time, some construction company can use the same Module F from previous example - extended level only - for their experienced project planners that are already familiar with basic 4D concepts and during the course they will work on a real project, learning the use of BIM server technologies and advanced 4D tools.

3.2 Module definitions

Definition of modules was arranged as three step process. In the first step, modules were identified and described in terms of module goals, learning outcomes, basic outline, assessment requirements and supporting literature. The main aim of the first step was to divide the content into manageable parts, to avoid duplication of the same content in different modules and to provide a mechanism to balance the amount of work required to reach the goals. The later aspect is especially important for university accreditation process. For business courses this aspect should be considered with regard to time available to professionals for learning purposes.

In the second step and based on the results of module definitions in the first step, learning content is described in form of storyboards. Learning content is collected and described in form independent of any method of delivery or presentation. Basic outline is structured in more detail into module blocks. For each block, content is described presenting general messages that should be delivered to students/participants and supported with links to literature, examples, cases, etc. It should be mentioned that some content is country specific with regard to codes or legislation. Storyboards do not cover these specific aspects and stay general, providing the basis for implementation in specific context. This kind of description can be used in the future by creative educators to prepare their own courses.

In the third step, one approach to presentation of the content was implemented for each module. For example, MS Powerpoint presentations were developed or Prezi presentations were developed for the module or in another example web pages were created delivering the content of the module. Learning content developed during the project is presented in English language and using industry “standard” document formats.

5. MODULE CONTENT

Content of the learning modules focuses on early design processes of construction project from both methodological and technological points of view. Learning modules cover topics such as:

SMART decision making framework: The Smart Decision Making framework (Schreyer 2010) is a systematic approach to evaluate the performance of virtual building designs and analyses. The reference for the evaluation is

a set of goals critical for the project success. Within the Smart Decision Making Framework (DMF) these goals are captured from the main stakeholders using the concept of Key Performance Indicators (KPIs). KPI evaluations are relative by nature since they base on the deviation of actually measured figures to initially set optimum figures for specific criteria. They can be formulated for objective as well as for subjective criteria. Smart DMF further proposes to discretely define the relation between the tolerance level for deviations and a respective dimensionless rating, using so called utility functions. To incorporate tolerances is necessary since project goals are in praxis often conflictive in their effects on each other; therefore it is generally seldom possible to achieve all goals to 100% at the same time. Since design processes are always characterized by such trade-offs, these have to be reflected by the concept using the Analytic Hierarchy Process for definition of priorities.

BIM collaboration hub: The main part of the Open Web-based ICT Platform for InPro is the BIM Collaboration Hub, which is based on the model server Share-A-space. For viewing and linking, the Solibri Model Server is used, and for model checking the Solibri Model Checker. Share-A-space is a commercial software in use at a number of industries and organizations. Share-A-space has all the functions required for the manufacturing industry for PDM and PLM collaboration and information consolidation. With the InPro additions and modifications, these generic functions are now available also for the construction industry. The BIM Collaboration Hub is designed using Share-A-space and is further developed and integrated with “IFC to PLCS” and “PLCS to IFC” mapping to fulfil the requirements of InPro. The PLCS and IFC toolboxes are commercial software products and used for integration of the software applications used in the InPro Key Processes. The Open web-based ICT platform is to be seen as a technical solution how to map the information available in the different applications, key processes and also the demonstrations of InPro.

Open BIM guidelines: The BIM Handbook targets two different readers, the inexperienced and novice reader who wants to understand the principle of BIM and whether it provides any value for his/her business, and the already experienced reader that needs a guideline for setting up BIM supported processes within a construction project, for its own involvement but also for the other project participants. The guideline then has to support the project requirements from the client perspective and the project work demand from the consultant and contractor side.

Energy analysis: Energy analysis is concerned by predicting the use and cost of energy in buildings and the assessment of heating and cooling demand based on comfort criteria. Energy analysis plays an important role in the early design of life cycle performance. Decisions taken early have a big impact on the overall energy efficiency, environmental performance and life cycle cost of the final building. Thus, energy analyses should be conducted before the structural and HVAC system design is finalized since the result will guide the structural and building service designer in the selection of structural system, the building shell as well as the selection of the HVAC system. It is important that energy and environmental analyst can actively take part in the design process, given the opportunity to affect the building design in the early phases of a project. This will guide architects, structural engineers and HVAC designers in a more sustainable direction.

BIM technologies and model based working: This module introduces the concepts and the practice of 3D modelling of buildings and the interoperability of CAD applications. The emphasis is put on understanding, creation and use of 3D models as a basis for design and collaboration in construction processes to overcome limitations of traditional 2D drawings.

IFC object versioning: The module is concerned with capturing BIM design development changes based on the object level rather than documents giving a lot of flexibility in conduction of partial model exchange as well as integrating data subsets coming from different sources, in addition to tracing design development history within its full context.

Client requirements: The module delivers information about importance of involving all relevant stakeholders from the beginning if a project including the client, starting from the project goals, identifying the relevant value

groups and values of the various stakeholders and deriving from these values the requirements for the project. The module stress the importance of performance parameters and (key) performance indicators to assess if the design fulfils the project goals including description of central processes and methods for the task, briefing process for documenting and communicating, strategic briefing (setting goals), operational briefing (collection of stakeholder values) and technical briefing (description of requirements, parameters and KPIs). It relies on Concurrent Design as engineering tool to support this process..

Bim based collaborative processes: The module focuses on collaborative processes during early design and design phases in a shared design environment. It covers topics like: clash detection and management, quality control (data consistency and exchange), change management (tracking), object status and version management (Maturity phases and Quality gates), alternative management (Design optimization), synchronization between private and public data, requirement and document management (incl. 2D Drawings).

Beside above mentioned modules, InPro developed learning modules that cover more traditional learning topics like scheduling methods, cost management and business models. Novelty in these modules targets model based approach to the topics.

6. CONCLUSION

In the context of information society, construction industry has been trying to adopt and take advantage of new collaborative software environments. For such fragmented industry like construction, computer mediated collaboration have great potentials. Flexibility in setting up project environments, knowledge sharing among project partners and making informed decisions from the very beginning of the project could be organised in new ways and be well supported by IT tools. Technology of Building Information Models and related work habits try to break through all the difficulties to become everyday construction project praxis.

To be able to utilize BIM technologies and better support transformation of construction industry InPro open information environment has been developed. Spreading InPro work practices into everyday project life is next step in IT supported integration of construction and therefore we are launching InPro training environment. Training environment brings together and shares the knowledge on model based working methods and supportive software tools. It is e-learning environment which delivers learning content for traditionally organized learning processes and that also provides on demand and location independent learning experience. Development of the environment takes into consideration integration of courses into existing and future university curricula as well as sharing of knowledge and best practices with business entities and construction professionals. Important part of the training environment is BIM laboratory, which provides problem oriented learning, where students and professionals can get hands on experiences with state of the art work methods and tools.

ACKNOWLEDGMENTS

This paper is a result of EU integrated project 026716-2 from 6th Framework Programme: InPro - Open Information Environment for Knowledge-based Collaborative Processes throughout the Lifecycle of a Building.

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