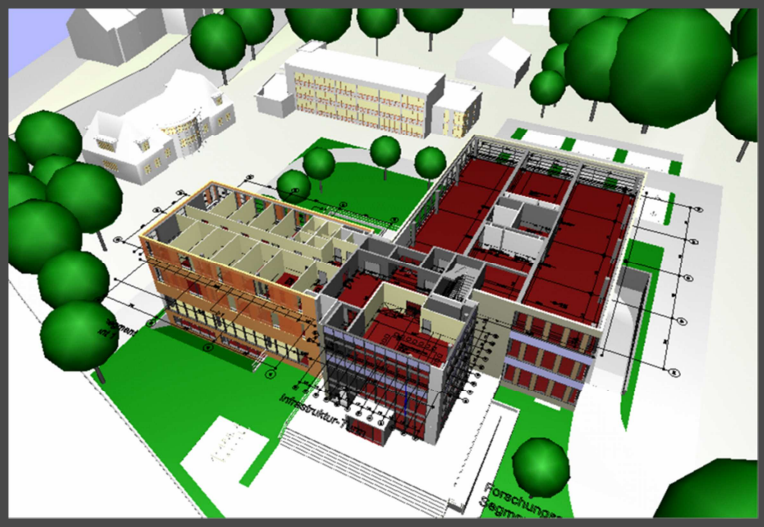
Open Information Environment
for collaborative Processes throughout
the lifecycle of a building

InPro Student Education Material



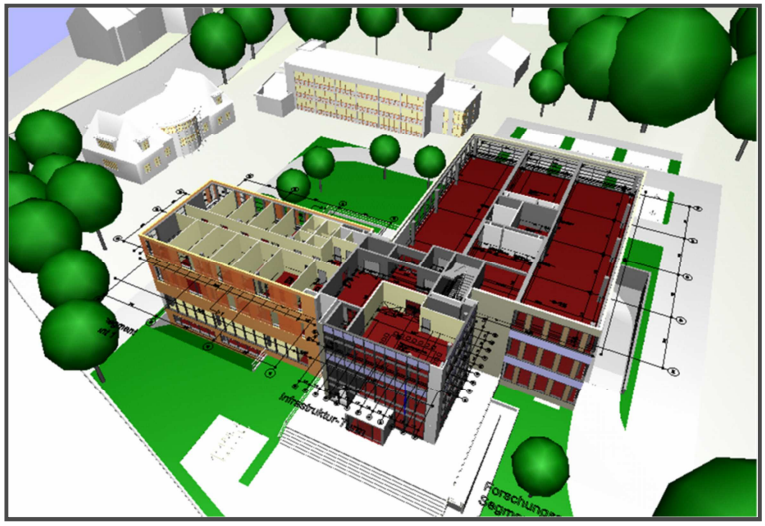
Ulf Ohlsson, Thomas Olofsson, Jutta Schade, Luleå; Nenad Cus Babic, Maribor; Mohamed Nour, Bauhaus; Lisanne Rommen, Dortmund

November 2010

The InPro project is an Integrated Project co-funded by the European Commission within the Sixth Framework Programme. More information about the project can be found at the web site: http://www.inpro-project.eu

REPORT

INPRO STUDENT EDUCATION MATERIAL



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EXECUTIVE SUMMARY

Material and curricula has been developed for university courses. This report presents five InPro learning modules which cover knowledge necessary to understand and to be able to work in "the InPro way".

The course material is based on use cases and demonstrations from InPro WP 5 and 6. All material is developed in English and based on Eurocodes. The material is adapted for distribution over the Internet using the training platform open for use by professionals in the AEC industry.

The following learning modules have been developed:

- *Smart Decision Making Framework* - to provide an understanding of the Smart Decision-Making Framework, which has been developed in the InPro project, as an approach of creating decision making support in a model based design process.

- *Model Based Energy Design* - to provide an understanding and knowledge of how to perform energy analysing in an integrated BIM driven design process.

- *IFC Object Versioning* - to provide a thorough understanding of the advantages of using an object versioning approach within a collaborative building information modelling environment against using the traditional document management systems.

- *BIM Technologies and Model Based Working* - to provide an understanding and the ability to use 3D CAD, BIM and application interoperability

- *InPro Business Model* – to provide an understanding of the theoretical framework of the InPro business concept and awareness about individual, project specific aspects

A *learning module* is a structured and more or less independent set of learning content that covers a specific subject area. Input requirements define prerequisites that students must already posses. For the module it is necessary to define learning outcomes as clearly as possible. According to learning outcomes, learning methodology, learning material, assessment methods and assessment criteria are defined. The learning modules can be combined to form different university curricula.

Learning modules consist of several *learning blocks*. Each block contains a number of *learning objects* with references and links to media components. The structure of the learning module is shown in the *storyboard*. The storyboard is targeted to the teacher and is useful for structuring and developing the course material. The course material and the storyboards for the learning modules are stored on the InPro training platform, see: http://inpro.itcedu.net

The introductory chapter 1 includes a brief background, the description of the aim and scope and the disposition of the report. Chapter 2 presents the organization of the learning process. This chapter gives the framework upon which the proposed learning material is based on. In chapter 3 the developed InPro Learning Modules are presented. The course descriptions are targeted to students. Appendix A contains survey results from given courses.

ABBREVIATIONS USED

Acronym	Explanation
AEC	Architecture, Engineering & Construction (industry)
BIM	Building Information Modelling
CAD	Computer Aided Drawing / Computer Aided Design
CAFM	Computer Aided Facility Management
D	Dimensional (like 2D, 3D, 4D)
DMF	Decision Making Framework
DX	Deliverable X [InPro]
HTTP	Hypertext Transfer Protocol [W3C]
HVAC	Heating Ventilating Air Conditioning
ICT	Information & Communication Technology
IFC	Industry Foundation Classes [IAI]
InPro	Open Information Environment for Collaborative Processes throughout the Lifecycle of a Building
LCC	Life Cycle Cost
LCD	Life Cycle Design
LCI	Life Cycle Inventory
OIP	Open Information Platform
SLP	Service Life Planning
T7.3	Task 7.3 [InPro]
WLC	Whole Life Cost

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1 INTRODUCTION

This chapter gives a short background, the aim and scope and the disposition of the report.

1.1 Background

InPro Work package 7 has developed tools, curricula and materials for training and education of management, architects, engineers, and construction workers, as well as university students.

InPro Task 7.3, University curricula, has developed a set of learning modules which 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 also fulfil the needs of business courses targeted to industry professionals.

The work in task 7.3 is related to task 7.1, Training platform, and task 7.2 Business courses. Task 7.1 has established a training platform for the InPro Open Information Environment based on existing solution for distribution of courseware and server based applications over the Internet. It has been implemented on a server open for development and integration/evaluation of new software tools after the InPro project has finished. The main goal of task 7.2 "Business courses" has been to support the industrial transformation to a *model-based and collaborative way of working in the early design phase, considering the whole lifecycle of a building* through curricula, tools and material for training of management, architects, engineers, construction workers, et cetera.

1.2 Aim and Scope

Material and curricula has been developed for university courses. The material has been adapted for distribution over the Internet using the training platform open for use by professionals in the AEC industry.

The course material is based on use cases and demonstration from InPro WP 5 and 6. All material is developed in English and based on Eurocodes. (Translation and adaptation to national rules is out of scope.)

1.3 Disposition of the Report

The introductory chapter, chapter 1, includes a brief background, the description of the aim and scope and the disposition of the report.

Chapter 2 presents the organization of the learning process. This chapter gives the framework upon which the proposed learning material is based on.

In chapter 3 the developed InPro Learning Modules are presented. The course descriptions are targeted to students.

Appendix A contains survey results from given courses.

2 ORGANIZATION OF THE LEARNING PROCESS

This chapter gives the framework upon which the proposed learning material is based on.

2.1 Introduction

Proposed framework tries to bring common grounds to the WP7 development process. For this reason we first define a set of terms that should be understood and shared by the partners and then we outline the framework structure.

2.2 Definitions

To simplify following descriptions and in context of InPro learning environment, students are formal university undergraduate or post graduate students and also practicing professionals from the industry who participate in any form of InPro learning process.

Learning outcomes

Like any other product, development of educational content needs definition of requirements. In case of education, ***requirements*** are formulated in form of learning outcomes.

Learning outcomes are defined for all educational units on every level of detail (for an entire curriculum as well as for a module).

Learning outcomes describe what the learning participant – the student - will be able to know, to understand, to do, etc. after completion of a specific learning unit.

Learning module

A learning module is a structured and more or less independent set of learning content that covers a specific subject area. Input requirements define prerequisites that students must already posses. For the module it is necessary to define learning outcomes as clearly as possible. According to learning outcomes, learning methodology, learning material, assessment methods and assessment criteria are defined.

For the purpose of InPro, a template for description of learning modules was accepted by task 7.3 members.

Study programme

Study programme defines the scope and context and represents ***outside view*** on the learning process. For study programme input requirements, outputs in form of general learning outcomes, educational level (undergraduate, masters, PhD) and time span are defined. Study programmes are usually defined by universities and should be accredited by national government.

Curriculum

Curriculum defines ***internal structure and content*** of a study programme. It is a group of interconnected learning modules and defines learning paths for students. It defines internal stages with requirements, which should be achieved to allow students to progress throughout the curriculum towards general learning outcomes.

ECTS - measurement of student workload

Learning modules put some workload on participating students. It is necessary to be able to measure this workload if the modules should be used in different contexts. In Europe there exists common understanding for such measurement and is defined as ECTS (European Credit Transfer and Accumulation System). In ECTS, student work is represented by credit points and one credit point means 25-30 hours of student work. ECTS points assigned to one learning module define how much time students need (on average) to meet learning objectives of the module.

2.3 Learning Modules in Detail

The aim of InPro with regard to education is to develop 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 fulfil the needs of business courses targeted to industry professionals.

In InPro focus is on end-user Key Processes that are chosen as business process fragments of model based working. However, focus on Key Processes is not suitable for organization of learning modules because KPs does not provide broader context and concepts. KPs are very good source of knowledge that we should use in formulation of learning modules. However additional mapping is needed as is illustrated in Figure 2.1.

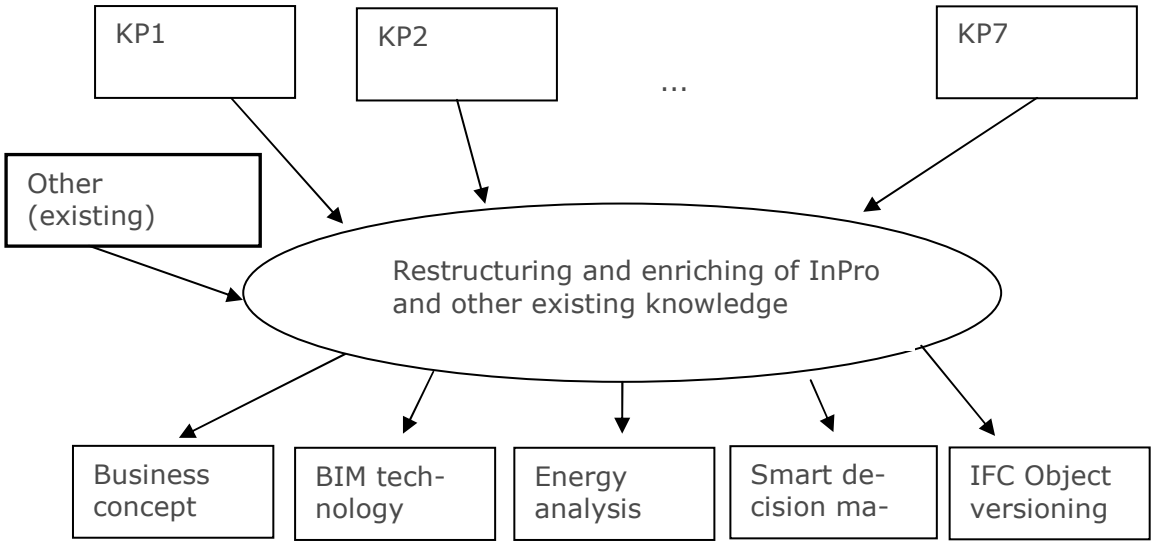

Figure 2.1: Mapping of information in the definition of learning modules

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.

The five course modules defined is selected to give an overview of concepts, processes, methods and technologies used in the InPro way of working, from definition of business requirements to speciality technology as IFC object versioning to prepare students for a research career within the field of building information modelling.

To meet specific needs and different levels of proficiency (existing and needed) the learning modules are structured in several levels of detail where each module contains three levels of detail which could be studied in sequence or independently, Figure 2.2.

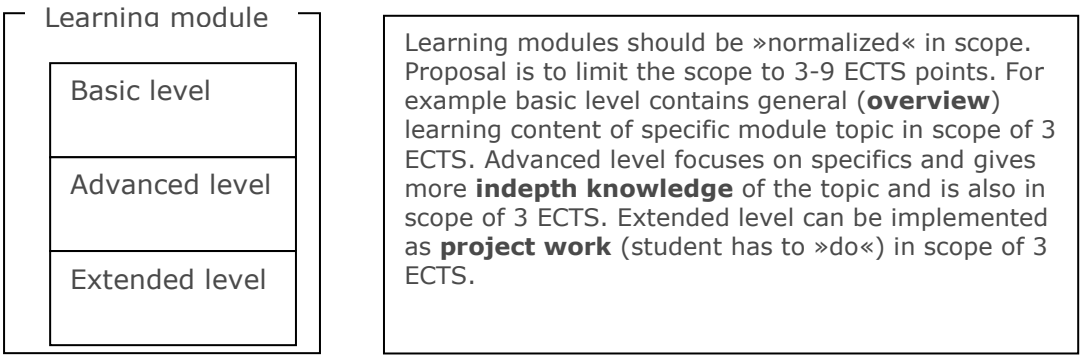

Figure 2.2: Proposed module layout

In this way it is possible to use the same learning modules in variety of contexts,

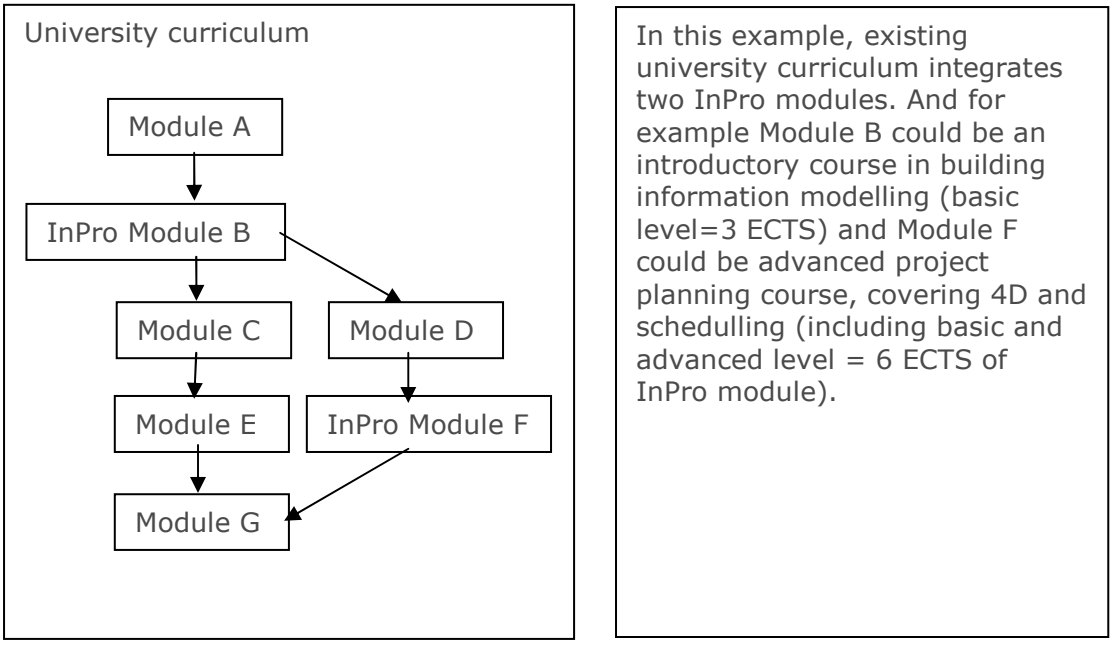

Figure 2.3: The use of learning modules in e.g. a university curriculum

At the same time, some construction company can use Module F (project planning) - 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 project learning the use of BIM server and advanced 4D tools. Or in another example, the company can use complete Module F for beginners in planning and model based working. The InPro project doesn't have to cover all levels of a module.

2.4 Recommendations for Effective Trainings

To avoid the duplication of work in tasks 7.2 and 7.3 and especially to develop student-friendly and understandable modules for both universities and business entities, the development of learning modules has followed the steps below:

1. Define clear learning outcomes. Start on a general level of the project – what students should know, understand and be able to do after accomplishing InPro learning objectives.
2. Group identified knowledge into learning modules and add broader content (like general building modelling topics) to the modules, to round them up.

3. Grouping includes balancing of student effort needed for finishing the module using common measuring technique. The ECTS system is used.
4. For each module detailed learning outcomes are developed and structured on three levels of difficulty/detail.
5. Modules are described according to the proposed module template: defining preconditions, aims, methods of work, structured content, assessment criteria with regard to learning outcomes and recommended reading.
6. Teaching materials are prepared for each module according to proposed content and methods of work using templates and tools developed in T7.1
7. Learning modules are peer reviewed (quality of content, quality of teaching material implementation), accepted by the project and published in InPro training environment.

When starting from learning outcomes instead of project tasks or Key Processes, quality of learning modules will be higher and the modules will be more flexible and more useful.

3 INPRO LEARNING MODULES

This chapter presents the developed InPro Learning Modules.

3.1 Smart Decision Making Framework

Module author: Thomas Olofsson, Luleå University of Technology

Module description: The Smart Decision Making framework 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.

Module aim: to provide students with an understanding of the Smart Decision-Making Framework, which has been developed in the InPro project, as an approach of creating decision making support in a model based design process.

Learning outcomes: abilities and skills the student will acquire

- *Concepts:*
  - Concepts related to the application of InPro decision making framework applicable in a model-based design environment.
- *Theories:*
  - Introduction to stakeholders values, Building Information Modelling and InPro Life Cycle Design methodology
  - Decision making concepts, the Analytical Hierarchy Process, SMART, utility functions and KPI
- *Methods and tools:*
  - Components of InPro's Decision Making Framework – Smart
  - The Smart excel tool
  - The use of Smart in the design process (Deliverable D10)

Module content (3 ECTS):

Table of Content of the module with percentage representing the learner's effort of different parts,

1. Introduction (15%)
   a. Objective: Motivation and overview of the learning content, the acquired knowledge and use
   b. Stakeholder values: Who are the stakeholders and how can we transform values into design requirements
   c. BIM driven design process: What is BIM, how can a BIM driven design process be organized. InPro's framework of LC design process with maturity levels and quality gates.
2. Decision making (35%)
   a. Decision making concepts and methods
   b. The Analytical Hierarchy Process - AHP
   c. SMART, utility functions and KPI

   d. Tutorial 1: AHP ranking of the area of geometrical shapes
   e. Tutorial 2: Construction of a utility function
3. InPro's Smart (20%)
   a. Components of InPro's Decision Making Framework – Smart
   b. Tutorial 3: Smart Excel tool: A Simple decision making scenario
   c. Tutorial 4: A more complex decision making scenario
4. Computer labs (30%)
   a. *Assignment 1 – A simple energy scenario*
   b. *Assignment 2 – A more complex operational scenario (hand-in)*

Learning and teaching methods:

Instruction is by means of condensed introductory in-class lectures (real classroom or virtual classroom) and consultations (virtual classroom). Audio visual aids are used by the tutor in the form of slide projections for presentation of content and to elaborate on lecture content and to stimulate discussion. The lecture programme will seek to introduce the basic theories and concepts of the subject matter and prepare the students for tutorials and for the assignment work. The tutorials will provide students with the examples of decision making scenarios and the use of model based design and result from analyses. Assignments will stimulate students to make strategies and use applications in order to present decision support for stakeholders in a model based design process.

Module prerequisites:

- Fundamental knowledge of project management and the design and construction process in the AEC (Architecture, Engineering & Construction) industry

Module Assessment:

Assessment Method	Grade	Proportion
Active participation	Pass/Fail	30%
Individual assignment	Pass/Fail	40%
Written report	Grade 1-10, (>3 for pass)	30%

Active Participation: Participation in computer labs is compulsory.

Assignments: Two individual assignments should be completed and approved

Written report: All students should write a short report (~5 pg) on the subject Decision Making Methods

Literature:

Shreyer et al, (2010), A smart decision making framework for Building Information Models http://www.inpro-project.eu/docs/InPro_SmartDecisionMakingFrameworkBIM.pdf

Recommend reading:

Olofsson et. al, (2010), The InPro lifecycle design framework for buildings, http://www.inpro-project.eu/docs/InPro_LifeCycleDesignFramework.pdf

Foreman and Selly, (2002), Decision by Objectives, http://www.amazon.com/Decision-Objectives-Ernest-H-Forman/dp/9810241437

Saaty, (2008), Decision making with the analytical herarchy process, Int. J. Services Sciences, Vol. 1, No. 1, 2008 http://inderscience.metapress.com/media/53f7mfa05p7jnk8b4meg/contributions/0/2/t/6/02t637305v6g65n8.pdf

3.2 Model Based Energy Design

Course authors: Stefan Dehlin and Katarina Heikkilä, NCC Construction Sverige AB; Jutta Schade and Ulf Ohlsson, Luleå University of Technology

Course introduction:

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.

Energy calculation methods can be divided in two groups, steady state and dynamic methods. Steady state energy calculations works by the same principles as manual calculation where incoming and outgoing energy flows of the building are considered. Indoor and outdoor temperatures are constant and free energy gains, such as solar radiation, are not usually taken into account. The dynamic method, considered in this course, is more complex and takes into consideration temperature peaks and the effect of the structures of the building as energy storage. Dynamic programs for energy calculations give the possibility to model the energy use with help of realistic thermo-dynamical models considering the requirements and indoor temperatures (Öberg, 2005).

It is important that the 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.

Although the number of building information models that are linked to performance simulation models is increasing and that there is several energy simulation programs linked to BIM design available on the market, there is still a limitation of the current BIM tools for energy analysis. Often the BIM models need to be complemented or even recreated to add the information required for the energy analysis.

The EU Directive 2002/91/EC from 2002 on energy performance of buildings will ensure that building standards in Europe have high emphasis on minimising energy consumptions.

Module objective: The main objective of this course is to provide course participants with an understanding and knowledge of how to perform energy analysing in an integrated BIM driven design process.

Learning objectives

After completion of the course the participant will be able to:

- Understand the concept of BIM
- Understand the principles of the InPro BIM-driven design process
- Understand the principles of energy analysing in a BIM-driven process and relate it to one or more everyday situations
- Understand the principles of the InPro energy analysis process
- Understand the difference from a traditional approach and be able to track the benefits (values)
- Be able to carry out BIM-based energy analysing (only Level 2 – energy consultants) and thus be able to present data for decision-making basis

The analysis result will support decision making and provide design alternatives through the design process, see figure 3.1.

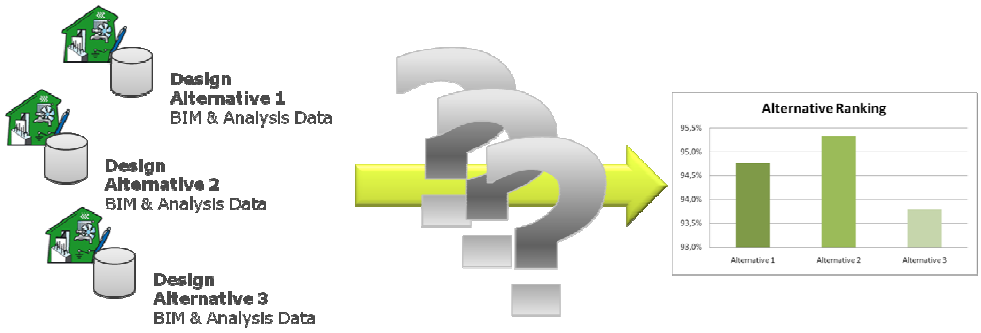

Figure 3.1: A formal decision making process

Module content (3 ECTS)

Table of Content of the module with percentage representing the course participant's effort of different parts,

1. Introduction (5%)
   Objective: Course outline, motivation and drivers for change, and overview of the learning content
2. Creating values in a BIM driven design process (5%)
   a. Values, requirements and briefing activities – how can we capture and then transform values into design requirements
   b. BIM and IFC in an integrated design process (what is…)
3. Theory of energy calculations (25%)
   a. Thermal loads (Indoor and outdoor climate)
   b. Theory of Heat transfer in 1D, 2D and 3D
   c. Applied Heat calculations in buildings
   d. Calculation of energy end effect demand
4. Energy (10%)
   a. Energy balance
   b. Energy requirements
   c. Theories of energy analysing
   d. Tools and methods used today and state of the art
5. InPro's energy analysing process (10%)
   a. [An introduction to] an integrated and concurrent BIM driven design process
   b. Introducing the concept of InPro's Life Cycle Design Process
   c. Energy analysis
   d. Change process – what is needed?
6. Demonstration and exercise (15%)
   a. Introduction to scenarios – prerequisites – data, formats, quality gates, limitations et cetera
   b. Demonstration of a real-life energy scenario
   c. Exercise – energy scenario – own work
7. Exercise 2 (30%)
   a. Introduction to exercise 2
   b. Exercise – energy scenario 2 – own work
8. Closure (-)

Learning and teaching methods:

The learning and teaching methods comprise both theory and practice – case-based

The course can be given thru in-class lectures or online lectures – *Virtual Classroom*.

Visual aids are used by the course leader for presentation of content, to elaborate on course content and to stimulate discussion.

The course will seek to introduce the basic theories and concepts of the subject matter and prepare the course participants for exercise work. The course literature will provide course participants with enough information to meet the learning objectives. The course participants take responsibilities; take controls of their learning objective. The course leader takes responsibility being the facilitator and tutor.

Course participants are required to perform exercises which help demonstrate achievement of learning outcomes.

The assessment will judge whether the learning objectives have been met.

Facilities and resources

Teaching rooms – in-class lectures, Internet – access to on-line books, websites and journals et cetera, and access to course management system Moodle – software, and hardware are supplied by course leader.

Demonstration and exercise – *IT teaching sessions* – will be held in computer labs: thru the Virtual Classroom or in in-class lectures, usually the same teaching room as the rest of the course.

Course prerequisites:

- Insight in the early stages of the construction design process
- Basic physics courses in thermodynamics

Module Assessment:

Assessment Method	Grade	Proportion
Active participation	Pass/Fail	50%
Individual assignments	Pass/Fail	50%

Active Participation: Attendance in lectures and demonstration – Real-life Energy Scenario.

Assignments: Two individual assignments should be completed and approved.

Literature:

Sormunen et al. (2009). Capturing stakeholder values – stakeholder values, stakeholder preferences and requirements for the life cycle design process. http://www.inpro-project.eu/docs/InPro_CapturingStakeholderValues_ValuesPreferencesRequirements_Public.pdf

Olofsson et al. (2009). The InPro lifecycle design framework for buildings.

http://www.inpro-project.eu/docs/InPro_LifeCycleDesignFramework.pdf

Recommend reading:

Further information about topics in "energy course" can be found in:

Benning P. et al. (2009). Framework for collaboration. http://www.inpro-project.eu/docs/InPro_FrameworkForCollaboration.pdf

Eastman C. et al. (2008) BIM Handbook – A guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors, John Wiley & Sons

Öberg M. (2005). Integrated Life Cycle Design - Applied to concrete multi-dwelling buildings. Doctoral Thesis. Lund University, Lund.

About VIP+ - an energy analysis software application – calculation of energy consumption, tutorial, see http://www.strusoft.com

About BIM and BIM based collaboration hub, see http://www.eurostep.com

3.3 IFC Object Versioning

Module Author: Dr. Mohamed Nour

Module Description: The AEC (Architecture, Engineering and Construction) design process is complex in nature. It includes a lot of iterative work and quality gates. In the meantime, modern construction practices include a lot of multidisciplinary work that has to be coordinated and done in parallel. The evolution and maturity of any design solution passes through several versions or alternatives (at either the entire design level or partial designs).

Most probably different design solutions (represented as alternative solutions or different development stages of the same solution as versions) have to be compared with the original design goals and intensions to test the conformance with client requirements. In this context, several metrics and indicators are developed to measure this conformance or performance of the design against constraints. Nevertheless, the clients themselves do change their requirements during and after the design phase.

IFC Object Versioning represents an advanced technology that supports *collaborative design* and *change management*. It is a tool that has been developed within InPro. It is based on IFC as a neutral data exchange format. Its main idea is based on capturing design changes on the object level (i.e. attributes of an object) and not on the basis of documents as in DMS (Document Management Systems). On the contrary to DMS, the object versioning system deals with a much finer degree of granularity which is the object and its attributes rather than documents. This gives more flexibility to the process of creating data subsets or partial models on one hand and enables the integration of data subsets coming from different sources on the other hand. In the meantime, an object version can still be linked to one or more documents with a document management system

It is also worth mentioning that there are several potential areas where this technology can be extended and applied, e.g. Knowledge Management, Building Corporate Memories, Organisational learning, etc.

The module represents an advanced topic, thus it should be taught within an entire building information modelling course. It mainly consists of three parts. Part one is an introduction to the nature of the design process with relevance to the technologies. Part two is an introduction to the basics of object versioning and the adaptation to IFC and the STEP technology. Part 3 is a practical implementation project / Group Assignment.

Module aim:

The main aim behind the IFC Object Versioning Module is to provide students with a thorough understanding of the advantages of using an object versioning approach within a collaborative building information modelling environment against using the traditional document management systems. In the meantime, the students should be aware of the main concepts and basics behind the object versioning technology away from any proprietary software development.

Learning Outcomes: Abilities and skills the learner will acquire in the following levels

Be acquainted with (lowest level)

- ***Concepts:***
  - The nature of multidisciplinary collaborative design processes, especially with emphasis on the design development through maturity

phases, quality gates, variants evaluation, support for decision making, etc.
    - The need for "change management": How is change management performed in today's practices with relevance to projects with various sizes, complexities and procurement systems?
    - Object Versioning as a "change management" tool.
- ***Theories:***
    - The abstract logic behind object versioning including the graph theory.
- ***Methods and tools:***
    - The manual application of the object versioning concept on simple examples that can be easily traced.

Understand and explain (medium level)

- ***Concepts:***
    - Concepts related to the application of object versioning on objects of the IFC model.
- ***Theories:***
    - The complete mathematical background of the object versioning concept.
    - Making use of the features related to "Object Oriented Programming".
- ***Methods and tools:***
    - The use of an object oriented programming language (e.g. Java, C++ or C#) to demonstrate simple versioning problems.

Apply (highest level)

- Concepts:
    - Concepts related to the IFC model and dealing with it objects.
    - Concepts of data sharing and ownership within the IFC model.
    - The InPro private workbench / workspace / sandbox concept for data sharing and consolidation.
    - Concepts to secure the IFC model information in terms of consistency through versions, correctness and management of change.
- Theories:
    - A back ground of the different Database Management Systems.
    - Appropriate Database schemata for object versioning.
    - Theories of relational and object oriented data structures.
- Methods and Tools:
    - Using BIM authoring tools and their ISO STEP 10303-21 IFC output to deploy an object versioning mechanism on real AEC design objects.
    - Dealing with shortcomings stemming from the BIM authoring tools.
    - Deploying the object versioning system within the InPro private workspace approach in relation to a central model server according to the developed InPro OIE (Open Information Environment).

Learning and Teaching Methods:

Type

- Lectures
    - 15 Lectures and seminars.
- Individual assignments
    - 1 Assignment to be solved on 5 stages.
- Project works
    - Final project that deals with real data from BIM authoring tools.

Distribution

- Asynchronous (self-paced tutorials, assignments, literature study, etc)
  - Assignments and project work
- Synchronous (face to face meetings, internet meetings)
  - 15 Lectures and seminars

Module content:

Table of Content of the module with percentage representing the learners effort of different parts,

1. Introduction (25%)
   a. The nature of the design process and the literature of design management
      i. Introduction to design management.
      ii. Introduction to knowledge management.
   b. The relation between object versioning and change management.
      i. Overview of document management systems versus Object versioning.
   c. Brief introduction to the IFC model.
      i. EXPRESS ISO 10303-11
      ii. STEP ISO 10303-21
   d. BIM Authoring tools and IFC model data exchange.
   e. Introduction to database management systems.
   f. The private workbench / workspace / sandbox concept.
      i. Introduction to the InPro Open Information Environment (OIE).
      ii. Role of the private workbench in the OIE.

2. Part A (35%) (Object Versioning)
   a. Introduction to Object Versioning
      i. Mathematical basis
         - Algebra of sets.
         - Graph theory. (Directed Graphs / Networks)
   b. Demonstrative Manual examples / exercises that includes:
      i. Design development through versions.
      ii. Variants Evaluation / Selection.
      iii. Capturing and Tracing Design development on the versioning graph.
      iv. Highlighting essential object attributes that are mandatory for versioning.
   c. Deploying and IFC Object versioning System for change management:
      i. Setting up the workspace and underlying database management system.
      ii. Connection with a central model server InPro OIP (Open Information Platform).
      iii. Examples / exercises on IFC object versioning.

3. Part B (40%) IFC Object Versioning Implementation Project (Students Group Assignment)
   a. The degree of difficulty should be determined by the course instructor according to the students' capabilities and background information.
   b. Projects would preferably be multidisciplinary projects that include students (actors) from different AEC fields to be able to demonstrate the achieved degree of interoperability. (e.g. Architects, Civil Engineers, HVAC, Cost Estimators, Project Planners/ Managers).
   c. Assessment Factors:
      i. An assessment factor would be the ability of students to be independent from any particular proprietary software solution.

ii. An assessment factor would also be the ability of students to freely select the deployed technologies and set up the communication platform (e.g. .Database Management Systems Central Model server, BIM authoring tools.)
iii. An assessment factor would be the ability of the students to overcome problems caused due to deficiency in the output from BIM authoring tools within the private workspace layer in order to guarantee the consistency and correctness of the models throughout their versions.
iv. An assessment factor would also be the ability to generate as much alternative designs as possible and the ability to compare, visualize and rank the alternatives as a sort of decision making support capability.
v. An assessment factor would be the ability to split and merge partial models at different stages of the design development.
vi. An assessment factor would be the dynamic ability and flexibility in responding to changes in clients' requirements by merging old variants to produce new model versions.

Module Assessment:

Example:

Assessment Method	Grade	Proportion
Active participation	Pass/Fail	15%
Group assignment	Pass/Fail	50%
Oral/written examination	Grade 1-10, (>3 for pass)	15%
Individual assignments	Grade 1-10	20%

Detailed description of what's required to pass the different assessment methods

Active Participation: At least 75% of the participation and active involvement should be achieved.

Group Assignment: At least 50% should be achieved.

Written Examination: At least 40% should be achieved.

Individual assignments: At least 50% should be achieved.

Module literature:

- Liebich T., Weise M. (ed), (2008): Open Standards for Interoperability between applications in Early Design (D6). Report of the NMP-EU Project InPro (IP-026716-2).
- Nour M. (ed), (2009): Overview of Information Management Applications, Including Object Based Versioning Management (D18). Restricted report of the NMP-EU Project InPro (IP-026716-2).
- Elmasry R. and Shamkant B. (2007), Fundamentals of Database Systems, Boston, Pearson / Addison –Wesley. ISBN: 9780-0-321-41506-6
- Melton Jim, Eisenberg A. (2000), Understanding SQLJ, JDBC and related technologies. The Morgan Kaufmann series in data management systems. San Francisco, USA. ISBN: 1-558-60562-2.
- Vad J. (2007), Textbasierte Objecktversionierung von Plannungsdaten für die Weiterverarbeitung in Ingenieuranwendungen. Diploma thesis, Bauhaus-Universität Weimar. (German language).

Recommended literature:

- Pahl, P. and Damrath, R. (2001), Mathematical Foundations of computational Engineering, A Handbook. Berlin, Springer 2001. ISBN: 3-540-67995-2.
- ISO 10303-21 (2002). Industrial Automation Systems and integration. Product data representation and exchange – part 21: Implementation Methods: Clear Text encoding for exchange structure.
- Building Information Modelling (2008), Transforming Design and construction to Achieve Greater Industry Productivity, smart market report. McGraw Hill Construction, New York. ISBN: 978-1-934926-25-3

Web references, journals and other:

- Nour M. and Beucke K. (2008), An Open Platform for Processing IFC model versions, Tsinguha Journal of Science and Technology, October 2008, pp. 126-131
- Richter T. and Beucke K.(2008), A concept for utilizing versioned object models in Engineering Applications. In Proceedings of the twelfth International Conference on Computing and Building Engineering (ICCCBE-XII), Beijing, October 2008. Tsinghua University.

Module prerequisites:

Students should have an awareness of the fundamental properties of:

- A background in civil / electrical / construction engineering, architecture or project management.
- Object Oriented Programming (data types, libraries, streams, logical statements, loops, lists, linked lists, stacks, queues, etc.)
- Database Management Systems: Relational / Object Oriented database management systems.
- Mathematics: Algebra of sets, Graphs, computational geometry.
- BIM authoring tools and 3D CAD modelling.

3.4 BIM Technologies and Model Based Working

Module Author: Nenad Čuš Babič

Module Description: This module will introduce the concepts and the practice of 3D modelling of buildings and the interoperability of CAD applications. The emphasis is put on understanding and use of 3D models as a basis for design and collaboration in construction processes to overcome limitations of traditional 2D drawings.

Module aim: to provide students with an understanding and the ability to use 3D CAD, BIM and application interoperability

Learning Outcomes: On completion of this module, the student will be able to

- describe the concepts and aims of 3D CAD and BIM,
- recognize the potentials of 3D CAD and BIM,
- identify and discuss interoperability problems and solutions,
- distinguish and describe 3D model representations,
- recognize and describe CAD model elements, functions and operations
- prepare data from different sources and integrate the data into 3D model
- construct or modify models in 3D
- share the models, combine tools and work collaboratively
- evaluate and present the models
- describe technologies and standards related to BIM

Learning and Teaching Methods:

Instruction is by means of condensed introductory in-class lectures (real classroom), tutorials (virtual or real classroom) and consultations (virtual or real classroom). Audio visual aids are used by the tutor in the form of slide projections mainly to elaborate on lecture content and to stimulate discussion. The lecture programme will seek to introduce the basic theories and concepts of the subject matter and prepare the students for tutorials and for project work. The tutorials will provide students with the examples of CAD applications, the use of BIM and the exchange of data between related software. Project work will stimulate students to use 3D CAD tools and exchange data between various related applications.

Module content:

1. Course background and objectives
2. AEC business model and design process
3. Modeling concepts, primitives and operations
4. Object oriented modeling and parametric modeling
5. Modeling tools
6. Model exchange & collaboration hub
7. Interoperability and standards
8. Project: practical example covering module content topics (adjusted to student background and specific work interests)

Module Assessment:

Assessment Method	Proportion
Active participation in class	30%
Project presentation	70%

Students must obtain a minimum of 60% in all assessment components of this module.

Active participation: Homework assignments and discussion topics will be hand out to students. Fulfilment of the assignments is checked regularly throughout the course. Students are stimulated for active participation and regular preparation for current lecture topic.

Project presentation: Students should prepare 3D building model of predefined complexity with tools of their choice and prepare project presentation. Every student prepares his/her own project. Students must present their ability to analyse, use and integrate data from different data sources, select appropriate tools, overcome interoperability problems and communicate their 3D designs in electronic format in variety of contexts. Knowledge and understanding of lecture's content should be demonstrated in project work.

Essential Reading:

Szalapaj, P., (2000), *CAD Principles for Architectural Design*, Architectural Press

Eastman, C., Teicholz, P., Sacks, R., Liston, K., (2008), *BIM Handbook, A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors*, Wiley

Recommended Reading:

Branko Kolarevic, Architecture in the digital age - design and manufacturing (2003), Taylor & Francis

Web references, journals and other:

http://itc.scix.net/

SketchUp, (2008), *Google SketchUp 7 Help*, Google Inc., http://dl.google.com/sketchup/gsu7/docs/en/SketchUp7Help.pdf

ArchiCAD 12, (2008), *ArchiCAD Interactive Training Guides*, Graphisoft Inc., http://www.graphisoft.com/products/archicad/training_guides/

InPro project deliverables and publications, http://www.inpro-project.eu/publications.asp

3.5 InPro Business Model

Module author: Mike Gralla, Lisanne Rommen, Technical University Dortmund

Module Description:

The InPro Business Concept is a new approach to support projects based on the InPro philosphy best. Organisational, contractual and payment aspects are not totally new but put in a new context to allow high level of collaboration and support the lifecycle approach. The consideration of the new way of working includes BIM which leads to new thoughts on solving risks, facilitate processes and finding a flexible structure with regard on contract features and incentives. Working in a team is a main focus – thus the team needs to be well prepared and well chosen. Within a competition of competences, all required competences can be evaluated to grant project success.

Module aim:

Understanding the theoretical framework of the InPro business concept and awareness about individual, project specific aspects.

Learning outcomes: abilities and skills the learner will acquire

- ***Concepts:***
  - Concepts related to the application of model based life cycle design in the early design stage.
- ***Theories:***
  - Similarities and differences between EU building regulations
  - National building regulations
  - Overview about international and national standard building contracts
  - Payment of building projects
  - Team building and team structures
  - Principles of Collaboration
- ***Methods and tools:***
  - Knowing the special requirements of collaborative projects (contract, remuneration, organisation)
  - Knowing the peculiarities about BIM in a business concept
  - To be able to evaluate and select team members

Module content (3 ECTS):

Table of Content of the module with percentage representing the learner's effort of different parts,

1. Introduction (30%)
   a. The nature of the design process
   b. Key issues of collaborative projects
   c. BIM and Virtual design in Construction
2. Building regulations and contracts
   a. EU regulations
   b. National regulations (VOB)
   c. Specification of international contracts (FIDIC, NEC, …)
3. Business Concept (70%)
   a. Team structures and organisation (Main actor, roles, Meetings)
   b. Team building (competition of competence)
   c. The possible barriers (risks, IPR, access rights)

d. Solutions for commercial and legal barriers (D 9b)

Learning and teaching methods:

The course is basically held in in-class lectures (mainly real classroom, virtual classroom possible) and consultations (virtual classroom). Slide projections are used to for present the theoretical content from the lecturer and later from the students to present each other results that are found during case studies, open for discussions. The lecture programme will seek to introduce the basic theories and concepts of the subject matter and prepare the students for the assignment work. The lecture programme will prepare students with examples of selecting teams (competition of competences). Assignments will stimulate students to make strategies and use applications to find an appropriate business concept constellation.

Type

- Lectures
- Case Study (if available)
- Individual assignments

Distribution

- Synchronous (face to face meetings, internet meetings)

Module prerequisites:

- Fundamental knowledge of the construction management and construction processes in the AEC industry

Module Assessment:

Example:

Assessment Method	Grade	Proportion
Active participation	Pass/Fail	25%
Oral/written examination	Grade 1-10	50%
Individual assignment	Grade 1-10	25%

Detailed description of what's required to pass the different assessment methods

Active Participation: At least 75% of the participation and active involvement should be achieved.

Written Examination: At least 50% should be achieved.

Individual assignments: At least 60% should be achieved

Recommended reading:

Gralla et. Al, (2009): Business Concepts –- State of the Art; InPro Business Concept, published through the InPro project

Kirchgassner, G. (2008): Homo Oeconomicus: The Economic Model of Behaviour and Its Applications in Economics and Other Social Sciences: Preliminary Entry 6 (European Heritage in Economics and the Social Sciences)

Eschenbruch, K.; Racky, P. (2008): Partnering in der Bau- und Immobilienwirtschaft, Kohlhammer Stuttgart.

Fröhlich, T. (2009): Kompetenzwettbewerb für partnerschaftliche Wettbewerbsmodelle, Technische Universität Dortmund.

Gehle, B.; Wronna, A. (2007): Der Allianzvertrag; Neue Wege kooperativer Vertraghsgestaltung, in: Baurecht, edition 1-2007, pp. 2-11.

Appendix A Survey Results From Given Courses

A.1 Report of the InPro Workshop for LTU Employees

Author: Jutta Schade

On 25th of August 2010 a workshop was given for LTU employees from different departments of the Luleå University of technology. This group is supposed to work interdisciplinary in a European Union Project together, called "nya Giron". The workshop organization from the InPro partners at the LTU was Thomas Olofsson and Jutta Schade. The goal of the workshop was: 'To translate knowledge and results from the InPro project to practical solutions for the research sector in Sweden and find implementation in further educations for students.

The location of the workshop was at Luleå University of Technology (Sweden). There were 18 participants in the workshop from different research groups (Architecture, Urban Water, Construction Engineering and Management; Traffic engineering, Industrial work environment).

The content of the workshop was a mixture of content from InPro WP 1.2, WP 2.3 and WP 2.4. The content which was used from InPro consisted of the following topics:

- A workshop about the InPro capturing values and design requirements
- A workshop about the InPro decision making method
- The client requirements workshop material
- The participants were given the opportunity to ask questions about InPro

10 of the 18 participants handed in an evaluation form after the workshop. The results of these forms are summarized in the following table:

Question	NA	No of answers	Highest answer	Lowest answer	Average
1 = strongly agree 2 = agree 3 = neutral 4 = disagree 5 = strongly disagree (6 = Not applicable)					
1.The goals and objectives for this course were made apparent	-	10	1	4	2,1
2.I understood the procedures and expectations for this course	-	10	1	4	2
3.The course materials were appropriate for the course objectives	1	9	1	3	2
4.The quality of the course material was good	1	9	1	2	1,8
5.The course leader was well prepared and structured	-	10	1	3	1,3
6.The course leader's feedback and commitment has been good	-	9	1	3	1,9
7.The practical parts of the course were good	-	9	1	4	2,1
8.I have been well prepared for the course	-	9	2	5	3,4
9.My work load was sufficient	-	9	1	3	2,1
10.Course technology was effective, sufficient and easy to use		8	1	2	1,8
11.The assessment of my learning was fair and related to the course objectives	-	9	1	3	2,3
12.My overall impression is that this was a good course	-	10	1	3	1,7
13.The course is going to be useful in my future work	-	10	1	3	1,9
14.I will recommend this course to others	1	9	1	3	1,9
15.Is there anything that you would suggest changing about this course?		1	The exercise was hard to interpret		
16.What worked really well in this course?		6	Examples; Discussion in the workshop; Smart excel tool was inter-esting; Was nice to work in groups; Good positive discussion environment; Discussion interdisciplinary		
17.Any further comments?		-			

A.2 Report of the Energy Module Implemented in the Student Course Building Physics at LTU

Author: Thomas Olofsson

In April-may 2010 the course building physics at LTU was given for 60 students in civil engineering and architectural program. A part of the course was (40%) was dedicated for the first version of the energy module. A total of 22 students answered the questionnaire and the result was used to improve energy course module.

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