Benedict
BIM-enabled Learning Environment for Digital Construction

BIM-enabled Learning - Toolbox for Assessment and Evaluation

Estonian Centre for Engineering Pedagogy
Tallinn University of Technology, Estonia
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Executive Summary

In this document a Toolbox for Assessment and Evaluation suitable for the BIM-enabled learning concept is presented. The purpose of the designed toolbox is to support BENEDICT project to meet its objectives and to offer contemporary tools for analysis, assessment and evaluation of the designed modules along with student learning. The scientific basis and design principles of the Toolbox are presented along with the designed pilot modules. The Toolbox comprises tools for assessment and evaluation both of which are described in this report.

1 Introduction

It is widely accepted that assessment tends to shape student learning, so if we want to change the way our students learn and the content of what they learn, the most effective way is to change the way we assess them (Fry, et al 2003). Authentic assessment focuses on the development of real-world skills, active construction of creative responses, and the integration of a variety of skills into a holistic project has an additional benefit.

Many current assessment systems do not allow learners to improve their own learning because the assessments are 'considered to be an endpoint instead of a beginning or a step forward'. This means that the assessment is summative (testing what has been learned) and therefore tends to drive the teaching (teaching for the test).

Assessment for learning (formative assessment) places more emphasis on the formative, is integrated into the curriculum and is context embedded and flexible. In practical terms this means assessment design which focuses on learning outcomes, supporting deep approach to learning, where the intention is to understand through an active constructivist engagement.

Important element of assessment design is incorporating feedback, reflection peer-assessment and self-assessment. This is a complex matter, involving the distinction between formative and summative assessment.

1.1 Background and purpose

Digitalization is driving changes in the Real Estate and Construction (REC) sector. A central feature of this digital transformation is Building Information Modelling (BIM) which refers to the integrated digital representation of all building-related information. The BIM-enabled Learning Environment for Digital Construction (BENEDICT) project is aimed at leveraging the emerging possibilities of BIM to enhance the education of REC professionals by developing an innovative, BIM-enabled Learning Environment which offers more realistic, immersive and integrated learning experiences.

BENEDICT has the following objectives:

- To specify the requirements for a common, openly accessible and flexible BIM-enabled Learning Environment (BLE)
- To develop a prototype BLE
- To create basic, generic content (learning resources) for the BLE
- To develop, test, implement and evaluate a series of innovative course modules that apply BIM-enabled learning using the BLE
- To develop guidelines and a handbook to enable the use of the BLE
- To provide training and instruction to stakeholders on the use of the BLE

1.2 The BIM-enabled learning concept

The BIM-enabled learning concept is based on the principles of experiential learning (Kolb 1984). Experiential Learning is the process of learning by doing. By engaging students in hands-on experiences and reflection, they are better able to connect theories and knowledge learned in the classroom to real-world situations.

When students participate in experiential education opportunities, they gain:

- A better understanding of course material
- A broader view of the world and an appreciation of community
- Insight into their own skills, interests, passions, and values
- Opportunities to collaborate with diverse organizations and people
- Positive professional practices and skill sets
- The gratification of assisting in meeting community needs
- Self-confidence and leadership skills

Learning that is considered "experiential" contain all the following elements:

- Reflection, critical analysis and synthesis.
- Opportunities for students to take initiative, make decisions, and be accountable for the results.
- Opportunities for students to engage intellectually, creatively, emotionally, socially, or physically.
- A designed learning experience that includes the possibility to learn from natural consequences, mistakes, and successes.

Kolb's (1984) cycle of learning depicts the experiential learning process (see **Figure 1**). This process includes the integration of:

- knowledge—the concepts, facts, and information acquired through formal learning and past experience;
- activity—the application of knowledge to a "real world" setting;
- reflection—the analysis and synthesis of knowledge and activities to create new knowledge.

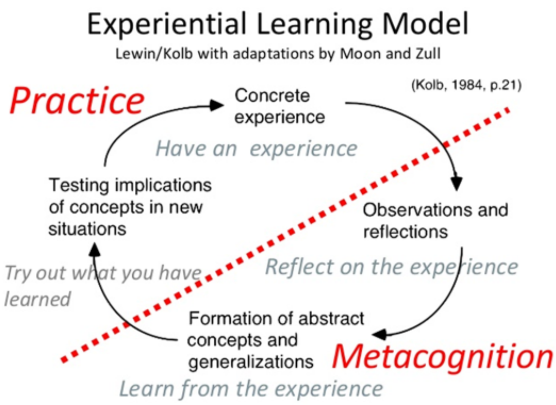

Figure 1 – Experiential Learning Model

In the phase of reflectiona and metacognition (**Figure 1**) students have to find answers to the following questions: What has been done? Who was involved? What were the different roles? What were the results? How was it experienced? What was the feedback? etc.

In the phase of learning from experiences students have to think about: What worked well and why? What didn't work well? Why did everything go that way? What could have happened? What impact can the curriculum / module / university / educational life have, etc.?

Before the phase of practice students have to think about: How to go on? What else to do? What to change? How to proceed in a similar situation next time? What would you recommend to others? etc.

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Experiential learning has the following elements (Association for Experiential Education, 2022):

- Experiences are carefully chosen for their learning potential (i.e. whether they provide opportunities for students to practice and deepen emergent skills, encounter novel and unpredictable situations that support new learning, or learn from natural consequences, mistakes, and successes).
- Throughout the experiential learning process, the learner is actively engaged in posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative, and constructing meaning, and is challenged to take initiative, make decisions and be accountable for results.
- Reflection on learning during and after one's experiences is an integral component of the learning process. This reflection leads to analysis, critical thinking, and synthesis (Schon, 1983; Boud, Cohen, & Walker, 1993).
- Learners are engaged intellectually, emotionally, socially, and/or physically, which produces a perception that the learning task is authentic.
- Relationships are developed and nurtured: learner to self, learner to others, and learner to the world at large.

In BENEDICT project the experiential learning theory works also in four stages—concrete learning, reflective observation, abstract conceptualization, and active experimentation. The first two stages of the cycle involve grasping an experience, the second two focus on transforming an experience. Effective learning is seen as the learner goes through the cycle, and that they can enter into the cycle at any time.

1.3 Objectives and scope of the assessment and evaluation toolbox

BENEDICT Toolbox of Assessment and Evaluation has been designed for assessment and evaluation of the pilot modules and for their improvement and further design. Evaluation of designed pilot modules includes student feedback, reflection, teacher reflectiona and course analysis.

BENEDICT Toolbox proceeds from the following point of view on assessment and evaluation.

- **Assessment** aims to enable learners to adjust their approach or study habits so that they can enhance their learning. Examples of assessment include implementing "mud cards," polling students to gauge understanding during the class, and assigning reflection papers. Assessment is a diagnostic tool focused on the learning of individual students, whereas evaluation determines the extent to which a program or pedagogy achieves predetermined goals or outcomes.
- **Evaluation** is a process that uses a variety of quantitative or qualitative techniques to analyse program, pedagogical, or course outcomes to determine whether they have been met. Evaluation is used in education in reference associated with curricula, programs, modules, methods of teaching and organizational factors. Evaluation determines the extent to which objectives are achieved. Evaluation is judgemental and based on the level of quality.

Key words of project-based learning for BENEDICT are:

- Challenging problems
- Cognitive flexibility
- Critical thinking and flexibility
- Discussion, student voice and choice
- Emotional intelligence
- Review and reflection
- Cooperation and collaboration
- Judgement and decision-making
- Scaffolding, engaging and managing
- Explanation "on-board" and "one-shot" learning

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- Communication
- Key-knowledge and deep understanding

All knowledge is formed as shared meanings in the collective actions of students. Students construct their understanding of the real-world problems, based on their previous experiences.

Evaluation is divided into tasks which are not strictly sequential: design of evaluation model/toolbox leading to the overall assessment, collection of quantitative and qualitative information, the analysis of the information collected, and formulation of conclusions and recommendations for further improvement.

Understanding the scope and scale of the educational activities which BENEDICT intends to measure is an important consideration in deciding and evaluation. Different frameworks and models that provide a starting point for analysis of designed pilot modules led to the decision to start from the analysis of intended learning outcomes (see the next section 1.4).

1.4 Scientific didactical background of the toolbox development

Scientific didactical basis of the toolbox development is relying on the holistic didactical approach, integrating the basic principles of Engineering Pedagogy Science, STEM didactics, didactical models for effective teaching STEM, constructive alignment (relevance of learning outcomes, teaching methodology, course content and assessment methods, see **Figure 2**).

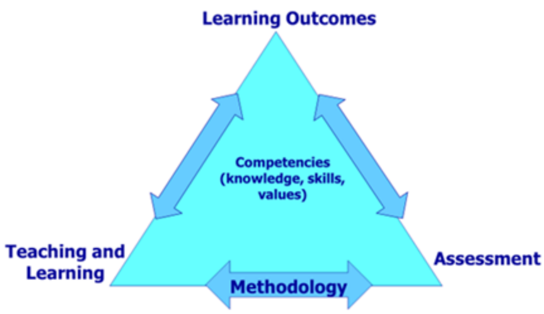

Figure 2 –Scientific didactical foundation of the toolbox

The following research-based didactical models have been integrated in BENEDICT methodology for Toolbox development and served as the scientific basis for analysis of intended learning outcomes (levels of didactical models start from supporting lower level thinking and reach higher-level thinking or critical thinking):

- Bloom's taxonomy levels – remember, understand, implement, analyse, evaluate, create;
- Feisel-Schmitz Technical Taxonomy – define, compute, explain, solve, judge;
- Webb's Depth of Knowledge - recall and reproduction acquired knowledge; skills and concepts - basic reasoning; complex reasoning – strategic thinking; synthesis of information – extended thinking;
- Hmelo-Silver's taxonomy for problem-based learning – explanatory knowledge, descriptive knowledge, procedural knowledge, personal knowledge and reflection;

The didactical models introduced above are integrated into the teaching and learning process and Evaluation Toolbox for pilot modules with the aim of supporting higher level learning (critical thinking and creativity), strategic and extended thinking, and reflection.

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1.5 Structure of this report

The structure of the present report is as follows:

- Review of existing evaluation models
- Pilot module design and description
- Assessment models for the pilot modules
- Assessment toolbox
- Evaluation toolbox

2 Review of existing evaluation models

Many contemporary evaluation approaches have emerged and a selection of these are reviewed below (Rüütmann, et al 2022).

Tyler's objectives-based evaluation. The objectives-based approach is particularly useful for evaluating programs that are narrowly focused and have clear, measurable goals (Stufflebeam & Coryn, 2008). Stufflebeam & Coryn (2014) opine that it is the most adopted approach among evaluators possibly because it is the easiest to use and appeals to common sense. However, what gives it its popularity is also its drawback in that it is considered too narrowly focused to be useful in evaluating a programme holistically (Stufflebeam & Coryn, 2008). It is also not useful for formative evaluation as findings are only available at the end of the programme being evaluated. As such it cannot be used in process improvement and susceptible to giving a false positive (Stufflebeam, 1983).

Wheeler's model. Wheeler's model of curriculum development and evaluation is an amendment of Tyler's model (Lau, 2001). Wheeler introduced the concept of continuity and developed a cyclic and flexible model of following steps: (1) define objectives and goals, (2) design learning experiences, (3) select course content, (4) organise learning experience, (5) evaluate.

Context Input Process Product (CIPP) model. The CIPP approach was conceived and conceptualised by Stufflebeam in 1969 based on his experience with the funding and implementation of the Columbus project funded through the Elementary and Secondary Education Act of 1965 (ESEA). The perceived deficiency in applying the prevailing evaluation techniques at the time (especially the Tylerian model) informed the development of CIPP by Stufflebeam and his colleagues to include both context and process evaluations in addition to the input and product evaluations that were already in use (Stufflebeam, 1983). As such, the CIPP model allows for some sorts of interim procedural evaluations (formative evaluations) especially where academics cannot easily determine the change in students' behaviour due to an intervention. Although the CIPP model was primarily developed for projects meant to improve educational access to the less privileged and to overhaul the general system of elementary and secondary education in the USA, several authors and authorities have adapted the approach for evaluating different objects (Anh, 2018; Stufflebeam, 2003).

Scriven's consumer-oriented approach. Scriven (1966) suggests two roles of evaluation for curriculum builders and argued that the two are equally useful depending on the goal of the exercise. The first he referred to as instrumental and the second as consequential. Instrumental evaluation involves "…the instrument itself; in the case of a particular course, this would involve evaluation of the content, goals, grading procedures, teacher attitude, etc.," (Scriven, 1966). Consequential evaluation deals with "…examination of the effects of the teaching instrument on the pupil, and these alone. It involves an appraisal of the differences between pre- and post-tests, between experimental group tests and control group tests, &c., on a number of criteria parameters" (Scriven, 1966). He argues that substituting instrumental evaluation with consequential evaluation is not the best. He however emphasised that these are roles of evaluation and not procedures of evaluation. In giving processual outline of how to carry out evaluation, Scriven (1966) states that establishing the relationship between goals and course content, goals and examination content; and course content and examination content are important to a successful evaluation.

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Stake's responsive evaluation. This approach was developed in the late 1960s as a replacement for "pre-ordinate" or experimental approaches, which paid little attention to the process and implementation of programs and had little engagement from stakeholders, including the beneficiaries, during the evaluation (Nyathi, 2020). The approach aims to expand the relevance of evaluation outcomes to a broader audience by de-emphasising goal-oriented approach to evaluation to provide different value perspectives of the stakeholders in reporting the success and/or failure of a program. According to Stake (1975) in Nyathi (2020), this approach is particularly useful during the early stages of a program, when stakeholders want to know what works and what doesn't, as well as how to improve program execution. Given the regular stakeholder communication and participation, one of the advantages of responsive evaluation is that practitioners do not need to wait for results until the evaluation is concluded but may start using findings during the process (Stufflebeam & Coryn, 2008).

Guba's constructivist, naturalistic evaluation. Guba's constructivist, naturalistic evaluation proposed a set of judgment criteria for constructivist evaluations that are akin scientific rigor, validity, and value standards (Stufflebeam & Coryn, 2008). The constructivist versions are credibility or trustworthiness, transferability beyond the studied context, dependability or reliability, and confirmability of data and data sources (Stufflebeam & Coryn 2008). One of the main points of these criteria is that the reliability and utility of an evaluation should be considered from the perspective of the evaluation report's users. Also, data are to be traced to their source and verified, and conclusions are to be assessed for logic, plausibility, and reasonableness. The strengths and weaknesses of this approach are well documented in (Stufflebeam & Coryn, 2008).

Patton's utilization-focused evaluation. Stufflebeam & Coryn (2014) described Patton's utilization-focused evaluation as one of the four "eclectic" evaluation approaches whose use case is primarily informed by findings. Other forms of eclectic evaluations are Owen's evaluation forms approach; the cluster evaluation approach; and various participatory forms of evaluation (Stufflebeam & Coryn, 2014). Stufflebeam & Coryn (2014) further state that eclectic evaluation theorists get their ideas, style, and taste from a wide variety of places. Their methods are tailored to meet the objectives and preferences of a diverse variety of evaluation clients and evaluation projects, with the goal of analysing a program without being bound by the limitations of a single model or methodology. As a result, evaluators that take an eclectic approach use whatever philosophical foundation, conceptual structure, and methods most conducive to attaining specific evaluation goals and satisfying the needs of specific evaluation clients.

Experimental design. The goal of the experimental and quasi-experimental design approach to program evaluation is to arrive at unbiased findings about the success or failure of a program (Stufflebeam & Coryn, 2014). Individuals, groups, or other units are randomly assigned to one or more conditions; a special treatment is given to one group and none (or an alternative treatment) to another; treatment conditions are held constant throughout the evaluation; and finally, a conclusion is reached (Stufflebeam & Coryn, 2014). Experimental and quasi-experimental design approaches have been used on diverse range of objects including employment; criminal justice; health care; cultural enrichment programs for children; preschool, elementary, and secondary education; distance education etc.

Case study evaluation. Investigators in case studies look extensively at the context, including program participants' demands, inputs, operations, intended and unintentional impacts, and any other processes (with all their intricacies) that are producing outcomes (Stufflebeam & Coryn, 2014). The portrayal of events, testimonies, stored data, and personnel participating in program implementation and direction are all prioritized so that stakeholders have the knowledge they need to understand the program and make necessary modifications. This data will unavoidably portray the multifaceted nature of the environment in which a program is taking place (Stufflebeam & Coryn, 2014). The authors surmised that an in-depth, noninterventionist investigation of a case and the issuance of illuminating report are the hallmarks of a case study evaluation.

Processes in evaluation approaches. Usually, evaluation approaches contain suggestions for several procedures or stages for implementing evaluation projects or programmes. The number of steps in the models varies, ranging from three to ten steps or processes (Olowa et al., 2021). These steps or processes are observed to be dependent of the philosophical background of the evaluation approach. Nevo (1983), in his review of major evaluation approaches in education, argued that there is no consensus among evaluation experts on the "best" process to use when conducting an evaluation. He, however, observed that

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most evaluators agree that all evaluations should include some level of interaction between evaluators and their audiences both at the start of the evaluation to identify evaluation needs and at the end to communicate the results. Nevo (1983) concluded that the technical activities of data gathering, and analysis are not sufficient for evaluation.

2.1 Related initiatives

Evaluation Models in Engineering Education. (Rüütmann, et al, 2022). In their review of over three hundred engineering articles and twenty-four general evaluation publications, Olowa et al., (2021) observed that engineering educators have been found to employ a variety of methodologies for evaluating engineering education for a variety of reasons, across a variety of time periods, and with differing degrees of complication. Major approaches they found include Accreditation Board for Engineering and Technology ABET, Baseline interview, longitudinal studies and portfolios, Web-based course for course evaluation questionnaires, Course panels and instructor reflective memos, QUESTE-SI (Quality system of European Scientific and Technical Education for Sustainable Industry), Student grades and SAPA (self- and peer-assessment). They further state that only the CDIO (Conceive-Design-Implement-Operate) standards, ABET, QUESTE-SI, and other educational board models appear to assist engineering education. The CDIO's creators argued that the model is more consistent, thorough, and detailed than other national and international standards such as UNESCO. The 12 CDIO standards form a solid basis for evaluation.

2.2 Existing initiatives with similar technical requirements

Taba's inductive model. Taba's inductive model was first proposed by Hilda Taba in 1971 for curriculum design and evaluation, described in her thesis Curriculum Development: Theory and Practice in 1962 (Taba 1971). The model considers the following six factors, to guide curriculum design and evaluation: (1) external factors (stakeholders), (2) content, (3) objectives, (4) teaching strategies, (5) learning experiences, and (6) evaluative measures. This model can be used in assessment and context and process evaluation, taking account of the expectations of stakeholders.

CDIO Standards. The 12 CDIO standards form a solid basis for evaluation.

IGIP Model of Engineering Pedagogy. The model was designed for design and analysis of engineering courses, taking account of the principles of STEM didactics with the following factors to analyse: (1) educational goals and relevant learning outcomes; (2) learners' prerequisites and individual differences; (3) course content and sequence; (4) learning environment and technology used; (5) teaching models, methods and strategies; (6) assessment methodology and evaluation; (7) reflection and further development of the course.(Rüütmann 2020).

2.3 Applicable standards

Applicable standards in the process of design, and assessment and evaluation of the pilot modules, suitable for experiential learning and problem-based learning in BENEDICT are:

CDIO http://www.cdio.org/

Washington Accord https://acreditaci.cl/en/engineering-accreditation/what-is/graduate-attributes/

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3 Pilot module design and descriptions

3.1 Pilot module design principles

The pilot modules are designed taking account of the scientific basis of problem-based learning (Hmelo-Silver 2004), social constructivism (Hofmann et al 2017) along with SECI model of knowledge creation by Nonaca and Takeuchi (Nonaka 1994).

SECI model states that we learn from sharing our ideas within the group and learning from each-other's experiences. Knowledge is created as a result of interpersonal communication and students' daily activities, supported by reflection and metacognition (Nonaka 1994). Nonaka and Takeuchi introduced the SECI model has become the cornerstone of knowledge creation and transfer theory. The acronym SECI stand for Socialisation, Externalisation, Combination and Internalisation and are phases that occur when tacit and explicit knowledge interact.

Social constructivism posits that individuals are active participants in the creation of their own knowledge, students learn primarily through interactions with their peers and teachers, whereas teachers stimulate and facilitate conversation through harnessing the natural flow of conversation in the classroom. Social constructivism suggests that successful teaching and learning is heavily dependent on interpersonal interaction and discussion, with the primary focus on the students' understanding of the discussion (Hofmann et al 2017).

According to Hmelo-Silver (2004) problem-based learning (PBL) approaches to learning have a long history of advocating experiential learning. Psychological research and theory suggest that by having students learn through the experience of solving problems, they can learn both content and thinking strategies. Students work in collaborative groups to identify what they need to learn in order to solve a problem. They engage in self-directed learning (SDL) and apply their new knowledge to the problem, reflecting on what they learned and the effectiveness of the strategies employed. The teacher acts to facilitate the learning process rather than to provide knowledge.

The goals of PBL include helping students develop (Hmelo-Silver 2004):

- extensive and flexible knowledge
- effective problem-solving skills
- SDL skills
- effective collaboration skills
- intrinsic motivation

BENEDICT pilot modules were designed on the principles of backward design methodology (see **Figure 3**):

- Identify desired results – design learning outcomes
- Determine acceptable evidence - consider the assessments and performance tasks students will complete in order to demonstrate evidence of understanding and learning.
- Plan learning experiences and instruction – design course content, select methodology

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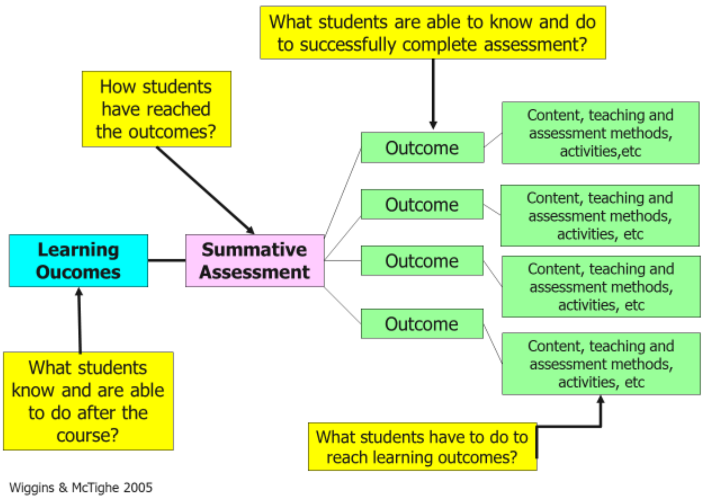

Figure 3 – Backward design of pilot modules

Learning outcomes of pilot modules were designed taking account of the different levels of Bloom's taxonomy for three types of learning: cognitive, psychomotor and affective (see **Figure 4**)

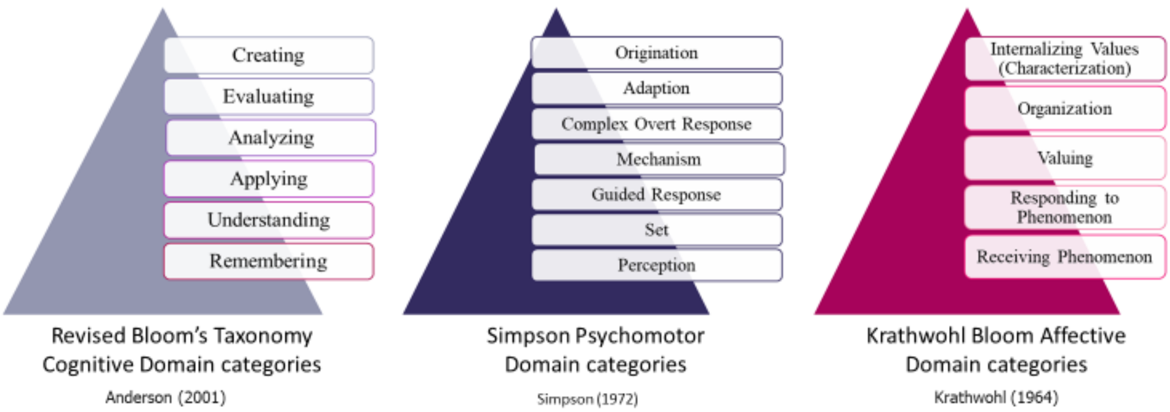

Figure 4 – Revised Bloom's Taxonomy for Cognitive, Psychomotor and Affective Domains

Methodology of teaching was designed according to Bloom's taxonomy and Model of Engineering Pedagogy. The analysis of methodology and levels of thinking supported by selected methodology (**Figure 5**)

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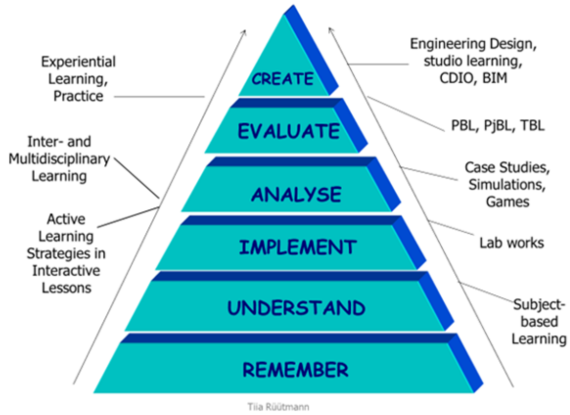

Figure 5 – Methodology used in BENEDICT program

Suitable teaching methods and strategies for effective teaching the designed content is selected and integrated for the design of a course/module methodology.

Methodology designed for BENEDICT pilot modules support higher level thinking and critical thinking along with strategic and extended thinking.

3.2 Learning Outcomes for Contemporary Engineering Education

Educational and professional accords for mutual recognition of qualifications and registration have developed statements of graduate attributes and professional competence profiles for engineers (Washington Accord Graduating Attributes https://acreditaci.cl/en/engineering-accreditation/what-is/graduate-attributes/). This document takes account of the present-day state of engineering activities, presents the background to these developments, their purpose, and the methodology and limitations of the statements (See **Figure 6**).

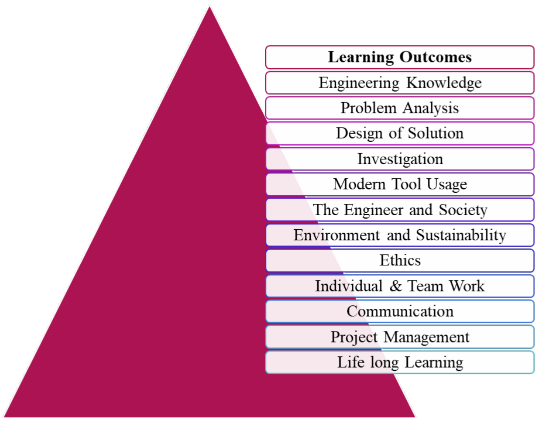

Figure 6 – Learning outcomes for Engineering Education

Based on academic research and McKinsey Global Institute experience in adult training Word Economic Forum 2021 defined 56 foundational skills, starting from four broad skill categories—cognitive, digital, interpersonal, and self-leadership—then identified 13 separate skill groups belonging to those categories (**Figure 7**).

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Figure 7 – 21st Century Skills by World Economic Forum 2021

Communication and mental flexibility are two skill groups that belong to the cognitive category, for example, while teamwork effectiveness belongs to the interpersonal category. These skills should be acquired during higher educational studies.

3.3 BIM-enabled Design Management at Concept Design Stage (Tampere University)

Course outline of the pilot module designed by Tampere University (TAU) is presented in Annex 1

Learning outcomes of the module

As learning outcomes of the module, the student:

- understands the preliminary and developed design stage processes, and their own role during both stages;
- understands the connection between different roles, design disciplines and design options
- is able to interpret design documents;
- is able to function in their role independently and collaborates and communicates with other stakeholders; and
- knows the common BIM requirements and is able to apply them into their role specific tasks.

Course contents

When the whole course includes simulation of the whole design process including concept, preliminary, developed and detailed design, and the actual design tasks, the pilot module will focus on the preliminary and developed design, and on the analysis, simulation and integration execution, not on the actual design tasks in the project.

Indicative topics (role specific, please see Teaching methods for more details on the roles):

- Spatial programme evaluation
- Design review
- Design schedule development

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- Cost estimation
- Model validation
- Model coordination
- Safety plan development
- Compliance

Teaching methods

This is a project-based module relying on social constructivism and students as independent (from teachers) learners. Students are organised into stakeholder groups (Client, Architect, BIM coordinator, etc.) and, to an extent, students' specialities (architecture, construction management, structural engineering, etc.). Depending on the students' specialities and number of students on the module, stakeholder groups' sizes vary from one student to multiple. Students work sequentially and in collaboration to analyse, simulate and integrate the building design using BIM model(s) and other available resources. Students work independently, both individually and as a project team. Faculty members' and industry mentors' role is to facilitate the process at agreed milestones, which include the design review meetings as a minimum. Students run the meetings. Facilitators' role in the meetings is to provide feedback and advice as needed. A kick-off lecture is offered to introduce the project. Supporting lectures on specific topics are offered during the module.

Delivery mode options for the module

- Fully online
- Mixed online and on-campus
- Hybrid (some online and some on-campus)
- **Fully on campus**

Students will work individually and collaboratively on a simulated project as needed to complete concept design stage activities. Faculty's role is to facilitate the process and to provide feedback and advice as needed.

Pilot Implementation

- Part of Construction Management course (5 credits)
- Year 2, Sustainable Urban Development, Bachelor's degree
- 7-week delivery (pilot module 4 weeks, 4 x 2-hour session) in September – October 2022
- 8-20 students with very limited understanding of building construction

Timeline of the TAU pilot module is presented in **Figure 8**

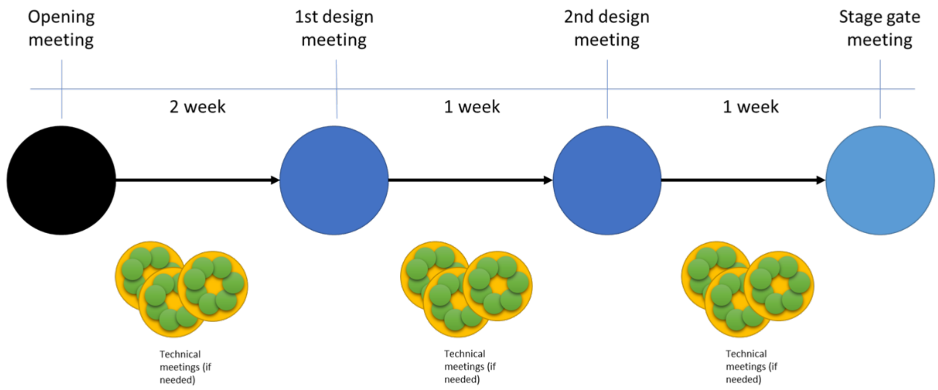

Figure 8– Timeline of the Pilot Module Designed by TAU

After the piloting

Fully online delivery facilitated by TAU:

- start with TalTech and UNIBO students

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- learners could be from different countries, either from the industry or from higher education

Other higher education institutes to deliver:

- start with the project partners TalTech and UNIBO

3.4 BIM-enabled Time Management in Construction Projects (University of Bologna)

Course outline of the pilot module designed by University of Bologna (UNIBO) is presente in Appendix 2.

Learning outcomes of the module:
After completing the module, the student:

- is able to describe the process, tools and techniques of project time management in construction (in a BIM-based work process).
- understands scheduling and project scheduling concepts.
- understands construction job site and site optimization concepts.
- understands the BIM work flow with respect to job site design, project time management and more generally.
- is able to apply the project time management process, tools and techniques in a realistic project scenario.
- can evaluate project schedule, estimate activity durations and resource allocation in terms of their relative significance towards total project duration.
- can critically analyze the construction job site and the industrial work-flow of operations in order to recommend improvements.

Teaching methods
The course includes in-class lessons and practical exercises. Teaching methods: in - class lessons, mandatory homework assignments and project- work. In-class lectures are aimed at learning methods and tools needed for project work implementation. Attendance in practical classes is recommended. Students work in groups.

Delivery mode options

- Fully online
- Mixed online and on-campus
- Hybrid (some attending online and some on-campus)
- Fully on campus

General process design. The module consists of:

- An introductory lecture – focus on BIM-based time management principles and process
- Three project planning workshops at the pre-construction and construction stages:
- Project Planning – focus on WBS creation, activity duration estimation (pre-construction stage)
- Project Job site design – focus on workplace design and construction processes (pre-construction stage)
- Project Scheduling – focus on Project Scheduling and BIM 4D (construction stage)

Delivery process map of the UNIBO model is presented in **Figure 9**

General timeline of the UNIBO model is presented in **Figure 10**

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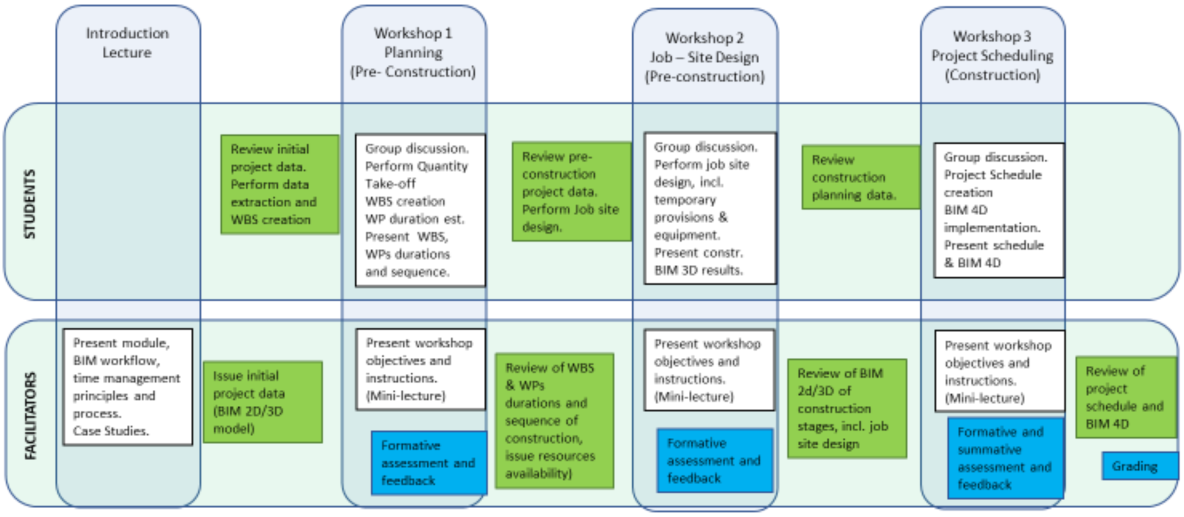

Figure 9 – General Process Map of the UNIBO model

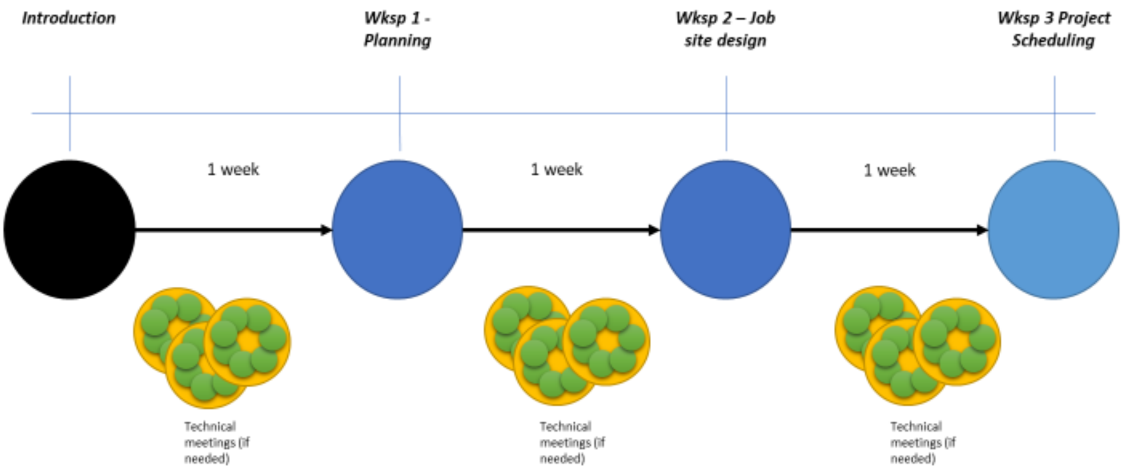

Figure 10– Delivery - Timeline of the UNIBO Module delivery

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3.5 BIM-enabled Risk Management in Construction Projects (TalTech)

Course outline of the Pilot module designed by Tallinn University of Technology (TalTech) is presented in Appendix 3

The expected learning outcomes for the course are as follows:

- Students are able to describe the process, tools and techniques of project risk management. With the BLE learning activity, this relates to a more realistic, detailed BIM-based process.
- Students understand risk and project risk management concepts.
- Students understand the BIM work flow (as the learning activity takes place within a BIM work flow, students also acquire understanding of this work flow - which increases the learning value beyond the risk management topic).
- Students are able to apply the project risk management process, tools and techniques in a realistic project scenario based on real project data and an industrial work flow.
- Within the given risk management process and project scenario, students are able to break up the scenario into constituent elements and analyse risks associated with each element.
- Students evaluate the risks identified in order to reach a collective judgement concerning the relative significance of each of the identified risks and appropriate mitigation actions.
- Students reconsider the risk management process and the industrial work flow in order to recommend improvements.

Experiential learning activity (Group work, lectures, discussions)

Students work through a guided, detailed project risk management process (including both qualitative and quantitative risk analysis) on the basis of real project data within a BIM work flow. They do so in teams arranged according to typical industry roles and, in the course of the activity, they explore and discuss in detail the following:

- The terms and concepts of risk management;
- The process of risk management in projects (plan risk management, risk identification, risk analysis, risk response, monitoring and control, documentation and record keeping / learning for future projects);
- Tools and techniques for achieving each stage of the risk management process;
- Project risk management standards;
- Risk management within the BIM work flow;
- Practical risk management on the basis of real project data;
- How risk and risk management link to wider ideas in construction, science and society (such as contracts as instruments of risk allocation and transfer, Integrated Project Delivery, statistical inference, climate change and disasters, societal risk and modernity, etc.).

Assessment methods

The course activities are undertaken in the form of group work. This is beneficial because the risk management process is best carried out by diverse groups with complimentary perspectives and experience. It also enables students to discuss their work in groups and learn from each other. Assessment, therefore, must also reflect this and the primary summative assessment tool is a group presentation and discussion - in essence a mini "defence" of the group's work. This is complemented by an individual learning reflection report which each student must complete and submit at the end of the course. In addition, participation metrics also influence students' final grades. (This also resolves the typical institutional expectation of individual grades for students).

Formative assessment in the form of short quizzes, discussion questions and reflections are regularly arranged throughout the course to ensure that a high level of student engagement is maintained.

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Learning approaches adopted for this course include:

- Problem-based learning (PBL)
- Experiential learning
- The CDIO approach which stresses engineering fundamentals set in the context of real-world systems and products

Delivery mode options:

- Fully online
- Mixed online and on-campus
- Hybrid (some attending online and some on-campus)
- Fully on campus

Delivery process map is presented in **Figure 11.**

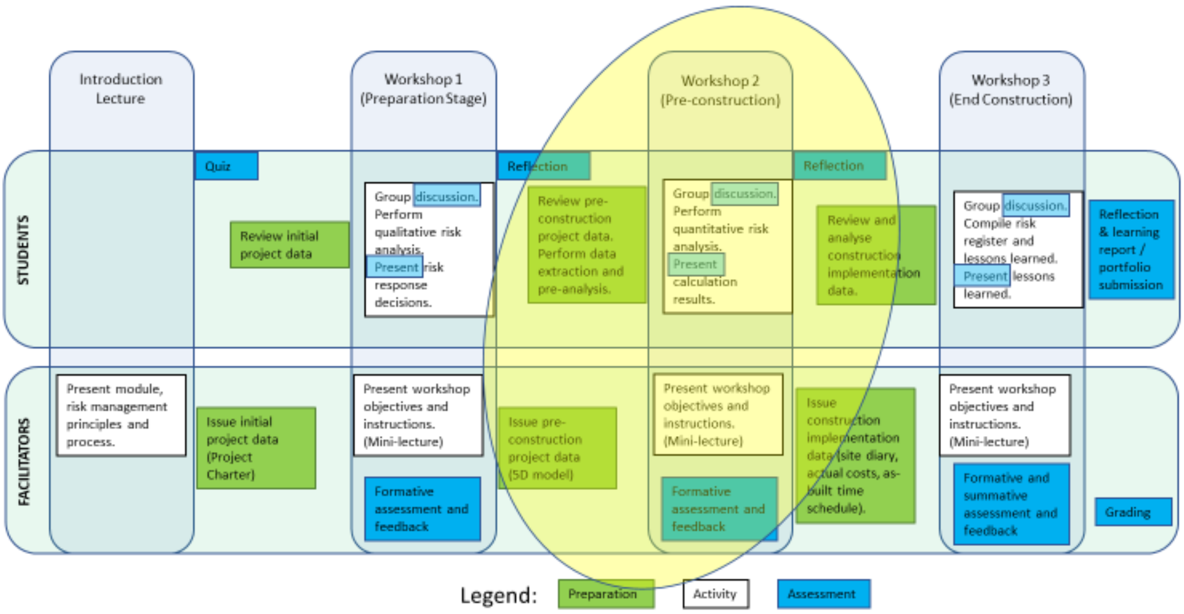

Figure 11 - Delivery Process Map of the TalTech Module

Typical week's activity is presented on Figure 12.

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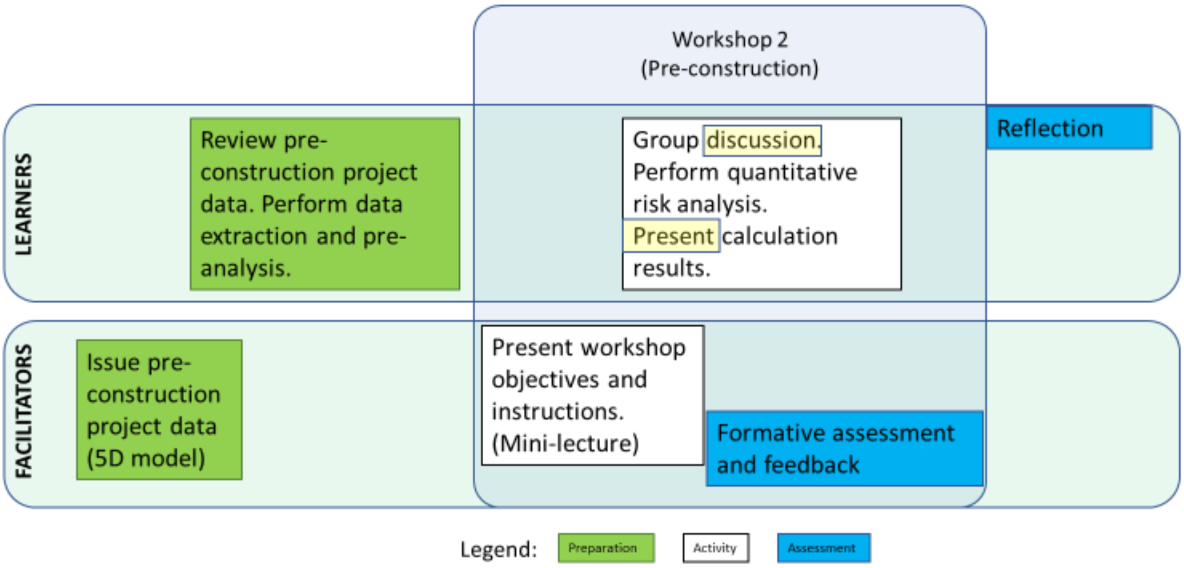

Figure 12 – Delivery - Typical Week's Activity

Timeline of the process is presented in **Figure 13**

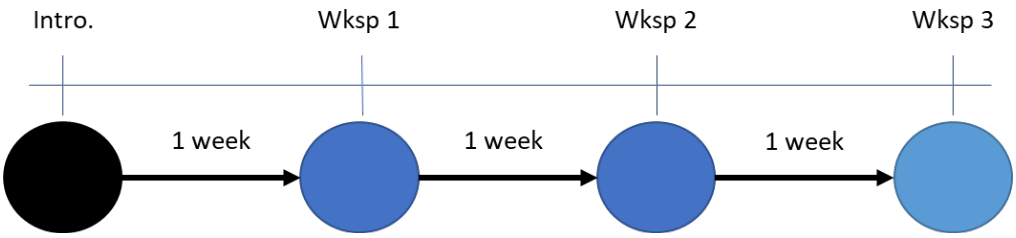

Figure 13– Timeline of the Process

3.6 Common module features, teaching methods and learning objectives

Teaching methods used in designed modules: discussions, group work, review, project work, quizzes, group work, individual learning, process analysis, lecture, mini-lecture, case study, risk analysis, design, workshop.

All pilot modules support students' critical thinking, learning with deep understanding. Pilot modules of TalTech and TAU also support the implementation of acquired knowledge. The comparison of learning outcomes of the designed pilot modules is presented in **Figure 14**.

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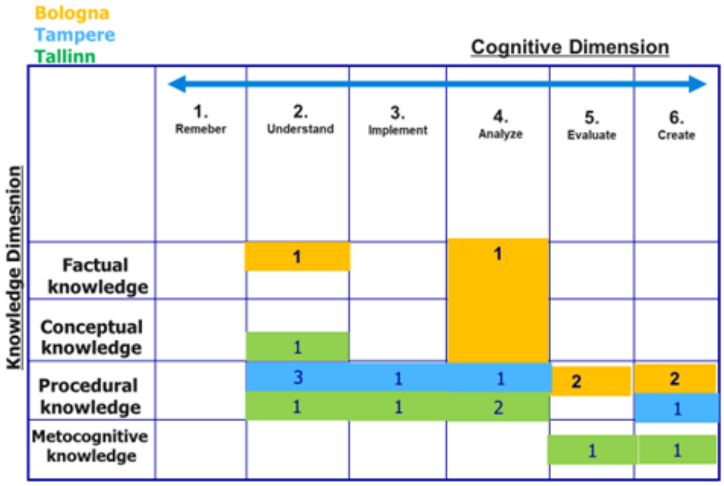

Figure 14 – Comparison of learning outcomes of designed pilot modules

Analysis of learning objectives of all pilot modules is presented in the following Chapter 4.

4 Assessment models for the pilot modules

Assessment is the process by which instructors evaluate what students know, think, or do during the course or as a result of a course or program. Instructors can use assessment results to make any improvements needed to the course and/or the curriculum.

Assessment modules have been designed for all three BENEDICT pilot modules:

- BIM-enabled Design Management at Concept Design Stage (Tampere University)
- BIM-enabled Time Management in Construction Projects (University of Bologna)
- BIM-enabled Risk Management in Construction Projects (TalTech)

4.1 Assessment Model for BIM-enabled Time Management in Construction Projects (University of Bologna)

Analysis of designed learning outcomes for the module have been analysed according to Bloom's Taxonomy (Anderson 2001) cognitive and knowledge dimensions. Five learning outcomes of six cover highest levels of critical thinking according to Bloom (supporting students to analyze, evaluate and create), one learning outcome covers the level on understanding, important prerequisite for learning with deep understanding (see **Figure 15**). Levels of thinking have been analysed according to Webb's Depth of Knowledge (Webb 2009).

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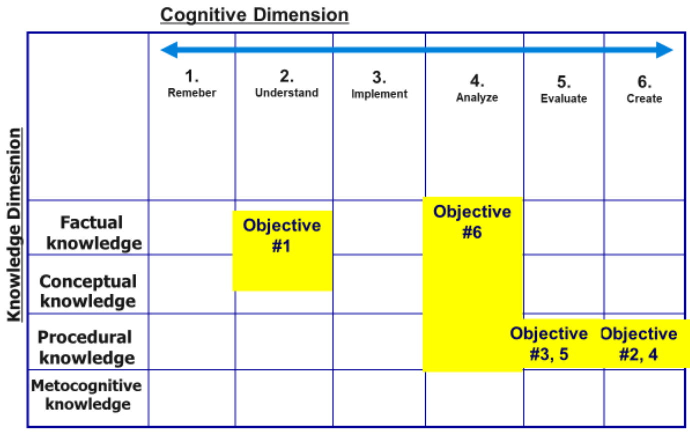

Figure 15- Analysis of learning outcomes of the pilot module

The assessment model, designed for this pilot module is presented in **Table 4.**

Table 4 – Assessment model designed for UNIBO pilot module

Outcome	**Level**	**Methods/thinking**	**Strategy/rubric**	**Summative**
Learn basic methods and instruments	Understand	Formative Summative Support basic reasoning	Test homework Rubric/criteria	Exam Rubric
Time and cost planning with quantitative models	Create	Formative Self-assessment Peer-assessment Reflection Support strategic thinking	Review/project criteria	Exam Rubric
Project control	Evaluate	Formative Self-assessment Peer-assessment Reflection Support strategic thinking	Review/project criteria	Exam Rubric
Design of construction operations	Create	Formative Self-assessment Peer-assessment Reflection Support extended thinking	Review/project criteria	Exam Rubric
Site optimisation	Evaluate	Formative Self-assessment Peer-assessment Reflection Support extended thinking	Review/project criteria	Exam Rubric
Safety	Analyse	Formative Self-assessment Reflection Support strategic thinking		

The module includes summative assessment (test, exam, homework and relevant grading rubrics) and formative assessment (reflection, self-assessment, peer-assessment).

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4.2 Assessment Model for BIM-enabled Design Management at Concept Design Stage (Tampere University)

Analysis of designed learning outcomes for the module have been analysed according to Bloom's Taxonomy cognitive and knowledge dimensions. Two learning outcomes of six cover highest levels of critical thinking according to Bloom (supporting students to analyze and create), one learning outcome covers the level on implementation, three learning outcome covers the level on understanding, important prerequisite for learning with deep understanding (see **Figure 16**). The process of learning is designed on the principles of experiential learning.

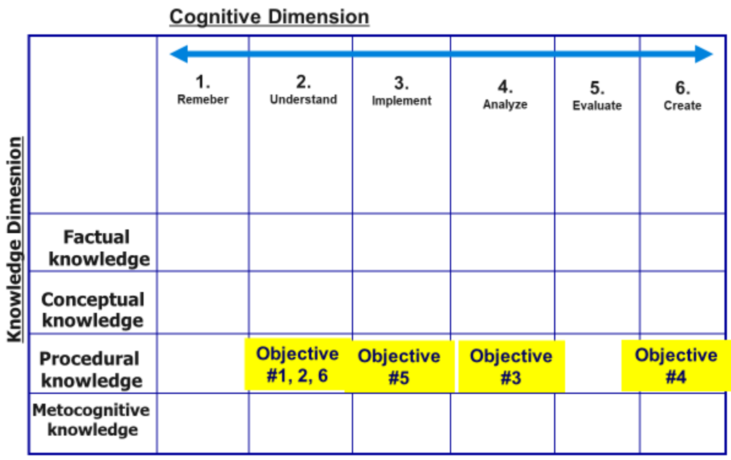

Figure 16 – Analysis of the learning outcomes of the TAU pilot module

The assessment module, designed for this pilot module is presented in **Table 5.**

Table 5 – Assessment Model designed for TAU pilot module

Outcome	Level	Method/Thinking	Strategy/rubric	Summative
understands the preliminary and developed design stage processes, and their own role during both stages;	Understand	Formative Self-assessment Reflection Support basic reasoning	Review/project	Pass/fail Criteria
understands the connection between different roles, design disciplines and design options	Understand	Formative Self-assessment Reflection Support Strategic thinking	Review/project	Pass/fail Criteria
is able to interpret design documents;	Analyse	Formative Self-assessment Reflection Support Strategic thinking	Review/project	Pass/fail Criteria
is able to function in their role independently and collaborates and communicates	Create	Formative Self-assessment Peer-assessment Reflection	Review/project	Pass/fail criteria

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with other stakeholders; and		Support Extended thinking		
knows the common BIM requirements and is able to apply them into their role specific tasks.	Application	Formative Self-assessment Reflection Support Strategic thinking	Review/project	Pass/fail criteria
understands the preliminary and developed design stage processes, and their own role during both stages;	Understand	Formative Self-assessment Reflection Support Strategic thinking	Review/project	Pass/fail criteria

The module includes formative assessment (reflection, self-assessment, peer-assessment).

4.3 Assessment Model for BIM-enabled Risk Management in Construction Projects (TalTech)

Analysis of designed learning outcomes for the module have been analysed according to Bloom's Taxonomy cognitive and knowledge dimensions. Four learning outcomes of seven cover highest levels of critical thinking according to Bloom (supporting students to analyse, evaluate and create), one learning outcome covers the level on implementation, two learning outcome covers the level on understanding, important prerequisite for learning with deep understanding (see Figure 17). The process of learning is designed on the principles of experiential learning.

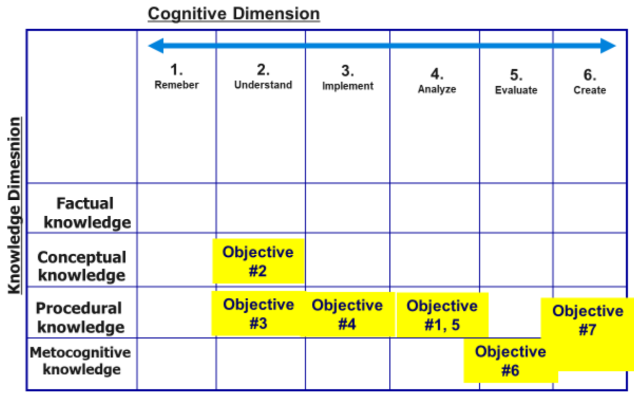

Figure 17 – Analysis of the learning outcomes of the TalTech pilot module

The assessment module, designed for this pilot module id presented in **Table 6**.

Table 6 – Assessment Model designed for TalTech pilot module

Outcome	Level	Method/Thinking	Strategy/rubric	Summative
Students are able to describe the process, tools and techniques of project risk management. With the BLE learning activity, this relates to a more realistic, detailed BIM-based process.	Analyse	Formative Self-assessment Reflection Support Strategic thinking	Quizzes Discussions Group work Individual learning report Participation metrics	Group presentation criteria

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Students understand risk and project risk management concepts.	Understand	Formative assessment Self-assessment Reflection Support Strategic thinking	Quizzes Discussions Group work Individual learning report	Group presentation criteria
Students understand the BIM work flow (as the learning activity takes place within a BIM work flow, students also acquire understanding of this work flow - which increases the learning value beyond the risk management topic).	Understand	Formative assessment Self-assessment Peer-assessment Reflection Support Strategic thinking	BIM workflow Discussions Group work Individual learning report	Group presentation Criteria
Students are able to apply the project risk management process, tools and techniques in a realistic project scenario based on real project data and an industrial work flow.	Application	Formative assessment Self-assessment Peer-assessment Reflection Support Extended thinking	Industrial work flow Discussions Group work Individual learning report	Group presentation criteria
Within the given risk management process and project scenario, students are able to break up the scenario into constituent elements and analyse risks associated with each element.	Analysis	Formative assessment Self-assessment Peer-assessment Reflection Support Extended thinking	Process analysis Discussions Group work Individual learning report	Group presentation Criteria
Students evaluate the risks identified in order to reach a collective judgement concerning the relative significance of each of the identified risks and appropriate mitigation actions.	Evaluation	Formative assessment Self-assessment Peer-assessment Reflection Support Extended thinking	Collective judgement Discussions Group work Individual learning report	Group presentation Criteria
Students reconsider the risk management process and the industrial work flow in order to recommend improvements.	Create	Formative assessment Self-assessment Peer-assessment Reflection Support Extended thinking	Discussions Group work Individual learning report	Group presentation criteria

The module includes formative assessment (reflection, self-assessment, peer-assessment).

4.4 Comparison of Assessment Models

In **Figure 18** the assessment methods used in designed pilot modules are presented. All pilot modules use formative and summative assessment. The course ends with grading (with relevant rubric) at UNIBO and pass/fail assessment (with relevant rubric) at TAU and TalTech.

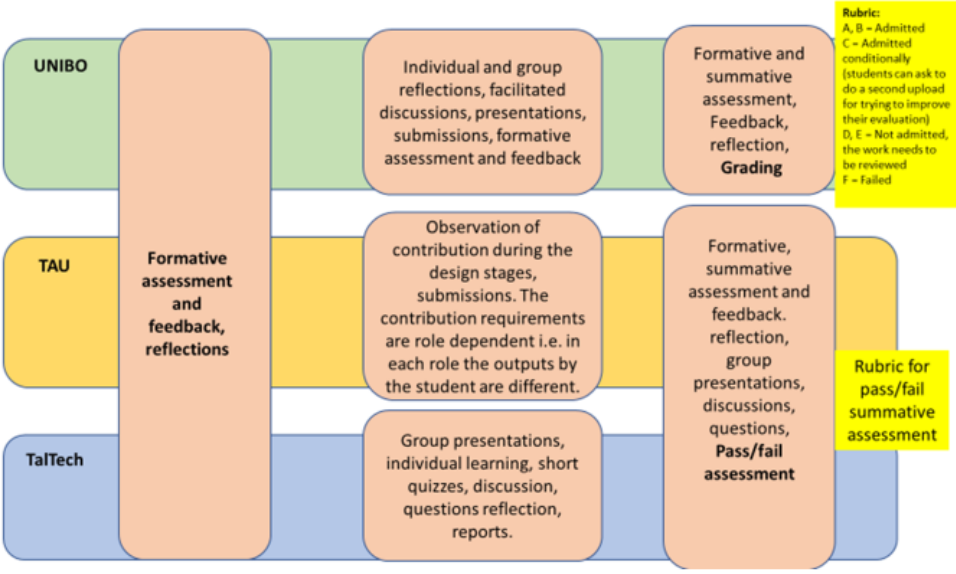

Figure 18 – Comparison of assessment Models

Feedback, reflections, self-assessment, peer-assessment, presentations, discussions, questions, quizzes, individual learning, reports are used in all designed pilot modules.

5 Assessment Toolbox

Below, in **Table 7** tools for formative and summative assessment of designed pilot modules are presented.

Table 7 – Assessment methods and Tools

Assessment method	Description	Tools
Summative Assessment	Assessment of learning. It assesses what has been learned in the past. It is usually graded, and serves as culminating activities for demonstrating student learning of an outcome. It provides feedback that ultimately can be used to improve the program(s) as a whole	•Traditional tools: Multiple-choice/short answer exams, Essay tests, Problem-solving tests, Research papers, Oral Presentations, Reports, Team Projects, Literature Review, Thesis/Dissertation, Lab report, Case studies, Concept mapping, homework, etc. •Alternative Tools: Group/Two-Stage Exams, e-Portfolios, Presentations, Quizzes, Visual Essays, Gaming, Simulations, etc.
Formative assessment	Assessment for learning, focusing on students' future achievement. It is usually ungraded, and provides instantaneous feedback for instructors. It provides teachers with insight of how well students are meeting the learning outcomes, and guides in terms of instruction:	•"On-site tools": Think/Pair/Share, World Café, Gallery Walk, Muddiest/Clearest Point, 1-Minute Papers, Application Cards, Brainstorming, Paper/Project Prospectus, One-Sentence Summary, Punctuated Lectures, etc. •"On-line tools": Poll Everywhere, Kahoot, Mentimeter, Slido, Linoit, Socrative, Quizlet, Online Surveys, Discussion Board (Canvas), etc. •Feedback and feed-forward •Reflection and metacognition •Self-assessment and peer-assessment
	Feedback	Recommendations for giving feedback:

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	Feedback is information given to the learner about the learner's performance relative to learning goals or outcomes. It should aim to (and be capable of producing) improvement in students' learning. Feedback redirects or refocuses the learner's actions to achieve a goal, by aligning effort and activity with an outcome.	•Ask the learners to evaluate themselves first •Give a coaching feedback – ask questions - What do you think…? •Focus on evidence - use the phrases "I saw… I noticed…" •Don't get personal, focus on the aims, observed behaviour, results, competencies, impact (possible consequences), etc. •Support self-analysis, self-esteem •Give recommendations, find together better possible results •Give suggestions for the future - encourage new patterns of behaviour •Draw up a plan of action for further improvement – give feed-forward •End always with students' reflection and ask them to say what they have learned
	Self-assessment	STARR method for supporting students' self-assessment. Follow the next steps (Strange & Mumford 2005): •S – situation; the circumstances, where the experience was received (for example, description of the workplace or a specific case). •T - task; the assignments and roles, which were completed during the learning process (which have to be related to what has been learned during the completion curriculum, considering that these tasks should also provide personal development). Here, you can introduce the problem that you will be paying further attention to. •A - activities; activities and methods (techniques, preparation, and principles for selecting the method and its alternatives). When describing activities, write what you did, how you did it, and what kind of methods/means you used. •R - results; the most important results (both the best and more surprising outcomes that made you analyse and change your activity), who, how, and based on what assessed, and what was done further with the results. •R - reflection; analysis, where the kind of competences you received and what are the areas that need improvement are reflected upon.
	Reflection and Metacognition	**Metacognition and reflection are the prerequisites of deep learning.** **Phases of metacognition:** •planning (targeting); •monitoring (implementation and analysis); •meaningfulness, analysis and evaluation (fulfilment of objectives, effectiveness of strategies, evaluation of the success of strategies and progress in achieving the objective, evaluation of errors and mistakes made in the process and the whole process, analysis, drawing conclusions; •planning further activities for self-development.

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		Metacognitive questions to support students' thinking (McKeatchie 2016): **At the beginning of the course:** •What are my expectations for this course? •What are the learning outcomes of the subject - what do I know and know after passing the subject? •What is my prior knowledge in this area? •What are my learning goals? •How do I adjust my time to complete all tasks on time? •etc. **During the lesson:** •What are / were the main ideas / topics for today's lesson? •What is / was difficult and confusing for me that I do not understand? •What should I ask the teacher / peers? •What other books / resources should I read? •Did I write down my questions, the main ideas of the lesson and the most important information? •What strategies or resources should I use if I have trouble solving the tasks? •etc. **Before the test/examination:** •What do I need to learn for this test and what do I need to know? •What is confusing to me that I should repeat to understand it deeply? •How much time should I have/plan to prepare? •Where can I study? In which learning environment? •Do I have all the necessary study materials? •What strategies would help me learn better (practice, questions, friends, repetition, teacher consultation, etc.)? •etc. **After the test:** •What did I not understand? Why was my answer wrong? •What mistakes did I make? What was the cause of the errors? •Was there anything surprising for me in the test? •Was I sufficiently prepared for the test? •What should I have done differently? •Did I receive the necessary, detailed and sufficient feedback from the teacher? •If I had to solve similar tasks next time, what should I do differently? •What did I learn from this test? •etc. **After completing the course:** •How did I do? What was I successful about?

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		•What should I pay attention to to improve my learning skills? •What new and interesting things did I learn in this course? •How can I use what I have learned in further studies, professional work? •What was interesting about this subject? •What was difficult? What took the effort? •What should I pay attention to in the future? •What else should I learn? •What do I do differently now? •etc. **Questions supporting reflection** •What are your most important experiences? •What are results you value the highest? What are you proud of? •How did you experience them? •What feedback you received from peers, teacher? •How you assess your own contribution? •What worked well? •How it works? •Why it works this way? •What were the mistakes? What caused the mistakes? •What could have been done differently? •How to avoid the mistakes next time in the same situation? •What effect/impact may it have …? •What to do and what to pay attention to next time? •What to change? •What may be the influence…? •What are the connections…? •What are the benefits…? •What if…? •What could have happened…? •What do you think, feel and believe? •What you recommend to the next students who have to do the same work? •What have you learned? •How can you use the experience in future? •etc

6 Evaluation Toolbox

The BENEDICT Program Evaluation Toolbox presents a step-by-step process for conducting a program evaluation. Program evaluation toolbox focuses on the practical application of program evaluation process and use best evaluation practices.

The toolbox includes nine steps that begin at the planning stages of an evaluation and progress to the presentation of findings to stakeholders.

Program evaluation starts with analysis of learning outcomes (on the basis of didactical models, for example Bloom's taxonomy) and ends with designing plans for further enhancement of the course (see **Figure 19**).

Each module (step) covers a critical step in the evaluation process (see **Table 8**).

Table 8 – Evaluation Tools

Evaluation step	Description	Tools
Analysis of Learning Outcomes	Analysis on the basis of didactical models used for planning and designing learning goals and learning outcomes, and professional standard	• Bloom's taxonomy • Feisel-Schmitz Technical Taxonomy • Webb's Depth of Knowledge • Hmelo-Silver's taxonomy for problem-based learning • Washington Accord Graduating Attributes • 21st Century Skills by World Economic Forum • Feedback
Analysis of the course Content	Analysis of the course content enabling to acquire lerning outcomes	• Washington Accord Graduating Attributes • 21st Century Skills by World Economic Forum • Professional standards • Reports, feedback
Analysis of teaching methods	Analysis of teaching methods enabling to learn the course content with deep understanding	• Feedback of students and teachers • Reflection • Questionnaires • Surveys • classroom/teaching observation
Analysis of assessment methods and criteria	Analysis of assessment methods enabling to assess whether the students have achieved the learning outcomes	• Feedback • Reflection • Questionnaires • Surveys, interviews
Analysis of learning activities and results	Analysis of learning activities enabling learning with deep understanding	• Feedback • Reflection • Final grades and results of pass/fail assessment • Questionnaires • Surveys
Analysis of constructive alignmentand learning environment	Analysis of compliance of learning outcomes, course content, teaching methodology and assessment methods	• Feedback • Reflection
Analysis of student feedback and reflection, peer-assessment		• Feedback • Reflection • Questionnaires • Surveys • Peer-assessment
Teacher reflection	Teacher reflection on the learning process, achievement	• Feedback • Reflection • self-assessment • Peer-observation of colleagues

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	of learning goals, learning results and student feedback	
Plans for further enhancement of the course	Curriculum design	• Feedback • Reflection • Feedback from graduates • Feedback from stakeholders • Questionnaires • Surveys, interviews

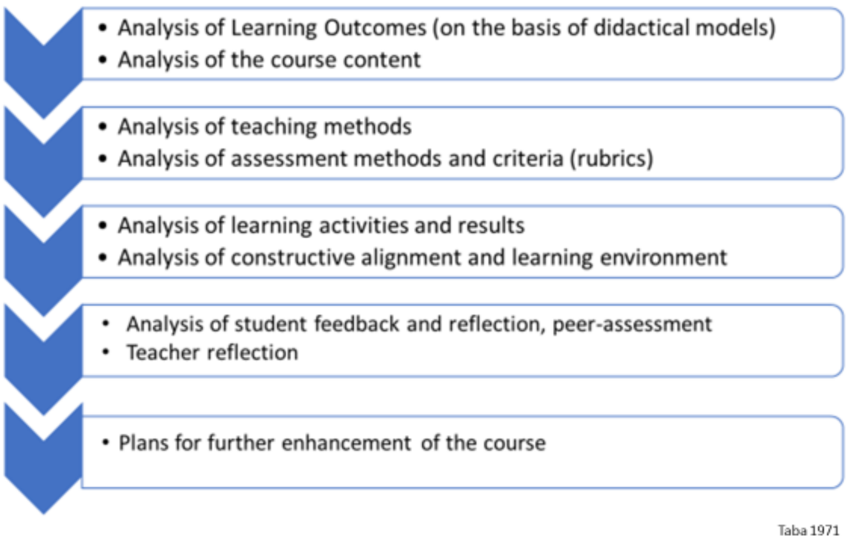

Figure 19 – Evaluation of the Pilot Module

Tools of BENEDICT evaluation toolbox are questionnaires, feedback, reflection, surveys, reports, presentations, interviews and observations, including classroom/teaching observation and peer observation, didactical models (e.g. Bloom's taxonomy), and self-assessment.

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ANNEX 1 - Course Outline of Tampere University (TAU) Pilot Module

University:	Tampere University	
Degree programme:	Civil Engineering (Master of Science (Technology))	
Course title:	Building Design Process Simulation	
University module code:	RAK.310 (module code number to be determined)	
Professor/Professors:	Kalle Kähkönen	
Academic Year:	2022/2023	
Basic information	Level:	Master
	Year of the degree programme:	1st or 2nd year of the Masters
	Number of Credits:	3-8 ECTS
	Duration - number of semesters:	2
	Duration - months:	8
	Number of hours:	80-215
	Which semester(s) of study programme:	Autumn and Spring
	Planned start / Planned end	Start of semester 1/End of semester 2
	Language:	Finnish
	Modules:	1
	Status:	Optional
	Minimum of compulsory hours of attendance	Not applicable
Additional information	Prerequisite courses:	No
	Complementary/subsequent courses:	No
	Presence of tutors to support teaching:	Yes
	Maximum number of students who can take the course (if the course is limited in number):	50
	Expected Number of students to attend the course:	40
Course contents	**The above information is for the whole course as the details for the pilot module have not yet been determined. However, this section and the ones below discuss the pilot module details.** When the whole course includes simulation of the whole design process including concept, preliminary, developed and detailed design, and the actual design tasks, the pilot module will focus on the preliminary and developed design, and on the analysis, simulation and integration execution, not on the actual design tasks in the project. Indicative topics (role specific, please see Teaching methods for more details on the roles): • Spatial programme evaluation • Design review • Design schedule development • Cost estimation • Model validation • Model coordination • Safety plan development • Compliance	
Learning outcomes	As learning outcomes of the module, the student • understands the preliminary and developed design stage processes, and their own role during both stages; • understands the connection between different roles, design disciplines and design options • is able to interpret design documents; • is able to function in their role independently and collaborates and communicates with other stakeholders; and	

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<table>
<tr><td></td><td colspan="2">knows the common BIM requirements and is able to apply them into their role specific tasks.</td></tr>
<tr><td>Explicit references to BIM learning</td><td colspan="2">Students use BIM in various ways on the module (role specific):
Conduct design reviews by interrogating the model(s)
Conduct design review meetings with the model at the centre
Evaluate the spatial programme and other client requirements by viewing and analysing the model
Estimate cost of the project by pulling out and measuring quantities from the model
Validate how well the models comply with the BIM Execution Plan
Coordinate the design by viewing the models and by using 3D coordination application.
Analyse the safety aspects of the project by viewing the model
Evaluate the compliance to town planning, legislation and regulations by analysing the model</td></tr>
<tr><td>Teaching methods</td><td colspan="2">This is a project-based module relying on social constructivism and students as independent (from teachers) learners.

Students are organised into stakeholder groups (Client, Architect, BIM coordinator, etc.) and, to an extent, students' specialities (architecture, construction management, structural engineering, etc.). Depending on the students' specialities and number of students on the module, stakeholder groups' sizes vary from one student to multiple. Students work sequentially and in collaboration to analyse, simulate and integrate the building design using BIM model(s) and other available resources. Students work independently, both individually and as a project team. Faculty members' and industry mentors' role is to facilitate the process at agreed milestones, which include the design review meetings as a minimum. Students run the meetings. Facilitators' role in the meetings is to provide feedback and advice as needed.

A kick-off lecture is offered to introduce the project.
Supporting lectures on specific topics are offered during the module.</td></tr>
<tr><td rowspan="4">Teaching tools</td><td>Tools:</td><td>Basic computer hardware</td></tr>
<tr><td>Software:</td><td>Model viewer, 3D coordination application, cost estimation application, basic office applications, communication applications, cloud service for project management</td></tr>
<tr><td>Platform:</td><td>BLE platform/Moodle</td></tr>
<tr><td colspan="2">All students use model viewers, basic office applications, communication applications and project management cloud service, when 3D coordination application is relevant to the BIM coordinator role and cost estimation application to Cost estimator.</td></tr>
<tr><td rowspan="5">Assessment methods</td><td>Type of exam:</td><td>No exam. See details below</td></tr>
<tr><td>Evaluation (score):</td><td>Pass/Fail</td></tr>
<tr><td>Estimated time for exams for each student</td><td>N/A</td></tr>
<tr><td>Number of exam sessions for each semester</td><td>N/A</td></tr>
<tr><td colspan="2">Assessment of the module is based on the student contribution during the design stages. The contribution requirements are role dependent i.e. in each role the outputs by the student are different.</td></tr>
<tr><td rowspan="6">Learning Materials

(Harvard Referencing Style)

Readings/Bibliography</td><td colspan="2">Core materials:</td></tr>
<tr><td colspan="2">Preliminary design stage: Project scenario including a conceptual architectural BIM model and feasibility study information
Developed design stage: Outputs from the preliminary design stage and further developed BIM models including architectural, structural and MEP models.</td></tr>
<tr><td colspan="2">Supplementary materials:</td></tr>
<tr><td colspan="2">As needed and to be determined</td></tr>
<tr><td colspan="2">On-line resources: (Weblinks):</td></tr>
<tr><td colspan="2">As needed and to be determined</td></tr>
</table>

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	Other materials (e.g. Videos, Monologues, etc.)
	As needed and to be determined
Any other useful reference regarding the course	

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ANNEX 2 - Course outline of the University of Bologna (UNIBO) Pilot Module

University:	*Alma Mater Studiorum – University of Bologna*	
Degree programme:	*Building Engineering (cod. 9199)*	
Course title:	*Cantieri e produzione edilizia T / Building Sites and Production T*	
University module code:	*30982*	
Professor/Professors:	*Marco Alvise Bragadin*	
Academic Year:	*2021-2022*	
Basic information	Level:	*bachelor*
	Year of the degree programme:	*3°*
	Number of Credits:	*6*
	Duration - number of semesters:	*1 semester*
	Duration - months:	*5 months*
	Number of hours:	*60 hours*
	Which semester(s) of study programme:	*1° semester*
	Planned start / Planned end	*20/09/2021-22/12/2021*
	Language:	*italian*
	Modules:	*1*
	Status:	*compulsory*
	Minimum of compulsory hours of attendance	*no*
Additional information	Prerequisite courses:	*no*
		(if yes, list)
	Complementary/subsequent courses:	*no*
		(if yes, list)
	Presence of tutors to support teaching:	yes
	Maximum number of students who can take the course (if the course is limited in number):	no max number
	Expected Number of students to attend the course:	30
Course contents	*1. Construction management – project management methods for planning, scheduling and controlling construction projects.* *1.1. Project Management for Building and construction projects:* *Project Management Body of Knowledge (PMBOK)* *Work Breakdown Structure (WBS)* *Construction schedule* *Building site construction phases.* *1.2. Planning and Scheduling: diagram-based methods (Gantt, S curves, load charts, Time/Space charts.* *1.3. Planning and Scheduling: activity networks:* *Critical Path Method (CPM)* *Precedence Diagramming Method (PDM)* *1.4. Resource planning and cost optimization:* *1.5. Project Cost Control for construction:* *Analysis of construction costs and prices* *Building Bill of Quantities* *Project Cost Management* *2. Building site organization and safety-oriented design.* *2.1. Building and construction site design:* *Building site stationings and systems* *Site logistics* *Infrastructural works construction site* *2.2. Technology and health and safety standards for construction:* *building site lay-out* *construction works, excavations and demolitions*	

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<table>
<tr><td></td><td colspan="2">scaffoldings
building site systems: electrical and handling systems (cranes)

<u>3. Construction Projects models and operators:</u>

3.1. Project management:
construction operators, construction law and regulations (Italy)
Direttore Lavori – Planning and works supervisor
Cost accounting for public works

3.2. Safety management in a construction company:
Laws and regulations (consolidated safety act)
Hazard assessement procedures
Safety managers and corporate roles

3.3. Safety management in a building construction site:
Laws and regulations (consolidated safety act)
Safety coordinators and owners' responsibilities
Construction site safety plans

4. Project work (groups of students):
Building site design and organization
Construction schedule (software MS project)</td></tr>
<tr><td>Learning outcomes</td><td colspan="2">To learn basic methods and instruments of construction management: time and cost planning with quantitative models, project control, design of construction operations, site optimisation and health and safety related issues.</td></tr>
<tr><td>Explicit references to BIM learning</td><td colspan="2">Students will integrate the BIM tools, in the development of the case study assigned to them. Students will have to model the building with Revit software or similar.</td></tr>
<tr><td>Teaching methods</td><td colspan="2">The course includes in-class lessons and practical exercises.

Teaching methods: in - class lessons, mandatory homework assignments and project- work.

In-class lectures are aimed at learning methods and tools needed for project work implementation. Attendance in practical classes is recommended.

Students work in groups.</td></tr>
<tr><td rowspan="4">Teaching tools</td><td>Tools:</td><td>Personal Computer</td></tr>
<tr><td>Software:</td><td>Revit, SketchUp</td></tr>
<tr><td>Platform:</td><td>Virtuale Unibo</td></tr>
<tr><td colspan="2">Students will also carry out building site visits in the construction stage.</td></tr>
<tr><td rowspan="5">Assessment methods</td><td>Type of exam:</td><td>submission of drawings + oral exam + written exam</td></tr>
<tr><td>Evaluation (score):</td><td>minimum grade to pass: 18/30
maximum grade: 30/30</td></tr>
<tr><td>Estimated time for exams for each student</td><td>written 90 min; oral 20 min</td></tr>
<tr><td>Number of exam sessions for each semester</td><td>3</td></tr>
<tr><td colspan="2">Achievements will be assessed by the means of a final exam. This is based on an analytical assessment of the "expected learning outcomes" described above.

In order to properly assess such achievement the examination is composed of different sessions: written session, which consist of a test, duration 2 hours, composed of exercises; to be eligible to take the oral exam the student must score in the written test a minimum total of 18 points with a maximum of 30.

The oral session, consists of: a review of the homework and a review of the written output, in which examiners inform the student on grading criteria, and receive any student appeal</td></tr>
</table>

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<table>
<tr><td></td><td>supported by appropriate explanations; and a technical conversation. Homework must be completed and passed prior the oral exam.

Higher grades will be awarded to students who demonstrate an organic understanding of the subject, a high ability for critical application, and a clear and concise presentation of the contents.

To obtain a passing grade, students are required to at least demonstrate a knowledge of the key concepts of the subject, some ability for critical application, and a comprehensible use of technical language.

A failing grade will be awarded if the student shows knowledge gaps in key-concepts of the subject, inappropriate use of language, and/or logic failures in the analysis of the subject.</td></tr>
<tr><td rowspan="8">Learning Materials

(Harvard Referencing Style)

Readings/Bibliography</td><td>Core materials:</td></tr>
<tr><td>– Bragadin Marco A., La programmazione dei lavori con i metodi reticolari, Maggioli 2010
– D.lgs. 81/08 e s.m.i. “Testo Unico sulla sicurezza sul lavoro” (TUS)
– D.lgs. 50/2016 e s.m.i. “Nuovo codice dei contratti pubblici di lavori, servizi e forniture”
– PMI, Guida al Project Management Body of Knowledge (PMBOK Guide), Ed. PMI, USA standard ANSI 99-001-2004
– Hendrickson C., Project Management for Construction, Carnegie Mellon University, USA.
– Bragadin Marco A. "La normativa per la gestione della sicurezza in cantiere" Maggioli, 2012
– Bragadin Marco A. " Scelte progettuali e sicurezza nel cantiere edile" Maggioli, 2012
– Moro A. "Il piano di sicurezza e coordinamento" Dario Flaccovio editore 2010
– Moro A. "La sicurezza in cantiere" Dario Flaccovio editore 2012
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– Semeraro G., Il cantiere sicuro, EPC
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– Frein J. P. (Ed.) Handbook of Construction Management and Organization. Van Nostrand Reinhold
– Lacava M., Solustri C.; Progetto e Sicurezza del Cantiere Ed.Carocci 1997
– Picone M. “Tecnologia della Produzione edilizia”, Utet, 1984.
– Auteri A. Dibennardo U. Pasqua A. “Il cantiere edile” NIS Roma 1996.
– Amato R. Chiappi R. “Tecniche di project management” FrancoAngeli, Milano.</td></tr>
<tr><td>Supplementary materials:</td></tr>
<tr><td>-</td></tr>
<tr><td>On-line resources: (Weblinks):</td></tr>
<tr><td>Class notes “virtuale” (www.virtuale.unibo.it)</td></tr>
<tr><td>Other materials (e.g. Videos, Monologues, etc.)</td></tr>
<tr><td>-</td></tr>
<tr><td>Any other useful reference regarding the course</td><td></td></tr>
</table>

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ANNEX 3 - Course Outline of Tallinn University of Technology (TalTech) Pilot Module

University:	Tallinn University of Technology	
Degree programme:	Structural Engineering and Construction Management (Integrated Engineering Masters programme) Building and Infrastructure Engineering (Masters programme) Building and Civil Engineering and Architecture (PhD programme)	
Course title:	Risk Management in Construction Projects	
University module code:	EPX---- (module code number to be determined)	
Professor/Professors:	Emlyn Witt	
Academic Year:	2022/23	
Basic information	Level:	Master / PhD
	Year of the degree programme:	4th year of (5-year) Integrated Engineering Masters programme, 1st year of (2 year) Masters programme, optional course for PhD students
	Number of Credits:	3 ECTS
	Duration - number of semesters:	1
	Duration - months:	4
	Number of hours:	80
	Which semester(s) of study programme:	2
	Planned start / Planned end	1st February 2023 - 31st May 2023
	Language:	English
	Modules:	1
	Status:	optional
	Minimum of compulsory hours of attendance	not applicable
Additional information	Prerequisite courses:	no
		(if yes, list)
	Complementary/subsequent courses:	yes
		EPX5310 Construction Investments and Project Management
	Presence of tutors to support teaching:	no
	Maximum number of students who can take the course (if the course is limited in number):	unlimited
	Expected Number of students to attend the course:	20
Course contents	**Introduction** (Lecture, discussion) • Instructions and information for participation in the course. • Formation of student working groups in key stakeholder roles. • Initial instructions to cover the essential pre-information necessary to commence • with the experiential learning activity. **Experiential learning activity** (Group work, lectures, discussions) Students work through a guided, detailed project risk management process (including both qualitative and quantitative risk analysis) on the basis of real project data within a BIM work flow. They do so in teams arranged according to typical industry roles and, in the course of the activity, they explore and discuss in detail the following: • The terms and concepts of risk management; • The process of risk management in projects (plan risk management, risk identification, risk analysis, risk response, monitoring and control, documentation and record keeping / learning for future projects); • Tools and techniques for achieving each stage of the risk management process; • Project risk management standards; • Risk management within the BIM work flow; • Practical risk management on the basis of real project data; • How risk and risk management link to wider ideas in construction, science and society (such as contracts as instruments of risk allocation and transfer, Integrated	

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	Project Delivery, statistical inference, climate change and disasters, societal risk and modernity, etc.).
Learning outcomes	The expected learning outcomes for the course are as follows: • Students are able to describe the process, tools and techniques of project risk management. With the BLE learning activity, this relates to a more realistic, detailed BIM-based process. • Students understand risk and project risk management concepts. • Students understand the BIM work flow (as the learning activity takes place within a BIM work flow, students also acquire understanding of this work flow - which increases the learning value beyond the risk management topic). • Students are able to apply the project risk management process, tools and techniques in a realistic project scenario based on real project data and an industrial work flow. • Within the given risk management process and project scenario, students are able to break up the scenario into constituent elements and analyse risks associated with each element. • Students evaluate the risks identified in order to reach a collective judgement concerning the relative significance of each of the identified risks and appropriate mitigation actions. • Students reconsider the risk management process and the industrial work flow in order to recommend improvements.
Explicit references to BIM learning	The idea of the BIM-enabled Learning Environment (BLE) concept is to enable immersive and integrated learning experiences on the basis of real, up-to-date project data from industry. This experiential learning takes place on the basis of a realistic industry work flow that fully utilizes BIM. BIM ensures comprehensive, organised and readily accessible project data. Much of this data is referenced directly to building objects (walls, beams, columns, windows, doors, floor slabs, pipes, etc.) which are represented in a virtual, 3D model of the building so that they can be easily viewed and understood. It therefore enables real, complicated project scenarios to be presented to and efficiently grasped by students. Using an industry BIM work flow ensures that the scenario on which the learning activity (project risk management, in this case) takes place corresponds to industrial reality and also that the data input to the learning activity (Data 1 in Figure 2) is not contrived by the lecturer but rather exists as real project data and is drawn directly from the same sources as would be the case in industry. (It should be noted that this project data must be prechecked and simplified to remove inconsistencies and unnecessary details which could confuse the students.)

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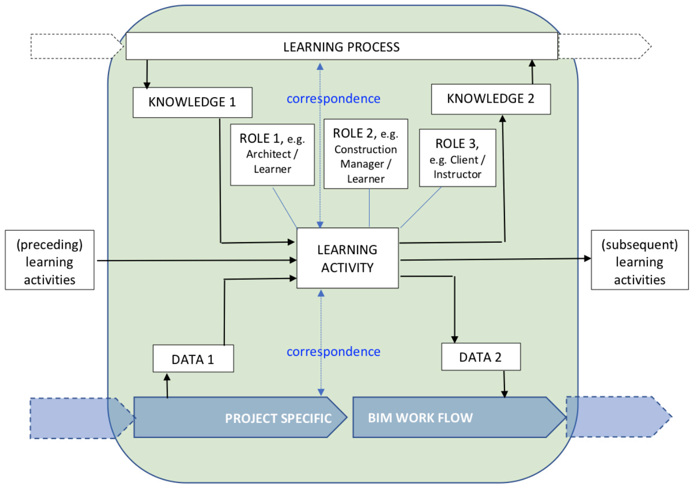

The BIM-enabled Learning Environment (BLE) (Source: Witt et al., 2020)

Similarly, by carrying out the learning activity, the project data is further processed and the output data (Data 2 in Figure 2) feeds directly back into the BIM work flow. The project is thus elaborated and progressed. In this way, the learning activity is intended to resemble a meaningful task in a genuine work context.
In order that students are suitably prepared and able to carry out the learning activity, they will need some pre-instruction (Knowledge 1 in Figure 2). However, most of their learning occurs within the context of the learning activity itself (Knowledge 2 - Knowledge 1 in Figure 2).
Ideally, the learning activity is a necessary step in the elaboration / realisation of the construction project. As such, the outputs of the learning activity will be fed back into the project (BIM) data and this, further elaborated project data, will become the basis for further learning tasks later in the project work flow. This potentially provides an opportunity to assess the quality of these learning activity outputs in terms of their subsequent usefulness later in the work flow.

Teaching methods

Learning takes place in groups and follows the roles of typical industry stakeholders (e.g. Client, Designers, Contractors, Regulatory authorities, etc.).
The mode of teaching is online with a mixture of synchronous activities (e.g. presentations and discussions) and asynchronous activities (preparatory work, individual contributions to groupwork, etc.)
A social constructivist model of learning is followed which acknowledges the (often considerable) prior knowledge and experience of the students in order to both build on it and also leverage it to enhance the learning of fellow students. Knowledge is considered to be sociall constructed, hence the emphasis on group work and discussion.
This does not, however, disclude the use of behaviourist learning approaches and individual activities.
Learning approaches adopted for this course include:

- Problem-based learning (PBL)
- Experiential learning
- The CDIO approach which stresses engineering fundamentals set in the context of real-world systems and products

Teaching tools

Tools:	Case study project data resources
Software:	(Any) IFC reader / model viewer
	(Any) Spreadsheet application
Platform:	BLE platform / Moodle

The BLE will serve as the delivery platform for the course and will also provide access to the repository of project data that will provide the input data to the learning activities in the form of one or more ifc files. During the learning activities, relevant data (including spatial geometric, time and cost data) will be identified, extracted and analysed for risk management.

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	Data analysis will be carried out using spreadsheet software applications. For deeper understanding of the project data for the learning activities, an ifc model viewer will be used. For editing / updating of the project data with the outputs of the learning activities, software enabling ifc file editing will be used.	
Assessment methods	Type of exam:	Group presentations, individual learning reflection reports.
	Evaluation (score):	100%
	Estimated time for exams for each student	Dependent on student numbers - approximately 10 minutes per student for group presentation.
	Number of exam sessions for each semester	1
	The course activities are undertaken in the form of group work. This is beneficial because the risk management process is best carried out by diverse groups with complimentary perspectives and experience. It also enables students to discuss their work in groups and learn from each other. Assessment, therefore, must also reflect this and the primary summative assessment tool is a group presentation and discussion - in essence a mini "defence" of the group's work. This is complemented by an individual learning reflection report which each student must complete and submit at the end of the course. In addition, participation metrics also influence students' final grades. (This also resolves the typical institutional expectation of individual grades for students). Formative assessment in the form of short quizzes, discussion questions and reflections are regularly arranged throughout the course to ensure that a high level of student engagement is maintained.	
Learning Materials (Harvard Referencing Style) Readings/Bibliography	Core materials:	
	Instructional video lectures / slides Case project data sets (to be compiled) Calculation templates / worked examples Formative Assessment - quizzes, discussion questions, reflection questions Summative assessment - group presentation template, discussion questions, reflection questions	
	Supplementary materials:	
	Various optional readings (to be determined)	
	On-line resources: (Weblinks):	
	All materials are provided on line.	
	Other materials (e.g. Videos, Monologues, etc.)	
	To be determined.	
Any other useful reference regarding the course	Olowa, T.; Witt, E.; Lill, I. (2021). Building information modelling (BIM) - enabled construction education: teaching project cash flow concepts. International Journal of Construction Management. DOI: 10.1080/15623599.2021.1979300. Witt, E.; Olowa, T.; Lill, I. (2020). Teaching Project Risk Management in a BIM-enabled Learning Environment. Proceedings of 23rd International Conference on Interactive Collaborative Learning "Educating Engineers for Future Industrial revolutions" ICL2020, 23–25 September,2020 Virtual Conference (TalTech, Tallinn, Estonia). Springer, 172–183. (Advances in Intelligent Systems and Computing). DOI: 10.1007/978-3-030-68198-2_14. Witt, E.; Kähkönen, K. (2019). A BIM-Enabled Learning Environment: a Conceptual Framework. In: Witt, Emlyn; Lill, Irene (Ed.). 10th Nordic Conference	

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	on Construction Economics and Organization, 2019 (271–279). Emerald. (Emerald Reach Proceedings Series ; 2). DOI: 10.1108/S2516-285320190000002051.

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