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IO4-WP4

Assessment report of BIMaHEAD e-course & guidelines for replicability

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Milestones and deadlines for all Partners:

Version	Partner	Date	Summary of activities and timeline
1.0.	Lodz University of Technology (TUL)	17.02.2023	First draft of the IO4 Report template. Sent to all Partners on 18.02.2023
2.0.	all	~~06.03.2023~~ 22.02.2023	Deadline for comments and feedback from all Partners. All agreed at the online Meeting on 22.02.2023
3.0.	Lodz University of Technology (TUL)	~~15.03.2023~~ 22.02.2023	Agreed the IO4 Report template distribution to all Partners. The template agreed at the online Meeting on 22.02.2023
4.0.	all	03.05.2023	Deadline for delivery of IO4 Reports from all Partners to the IO4 Leader (TUL) – all must be finished by 03.05.2023 apart from the Final Conference outcomes that will be added after the event.
5.0.	Lodz University of Technology (TUL)	17.05.2022	First draft of the final IO4 Report completed and shared with Partners for their feedback.
6.0.	all	23.05.2023	Deadline for the feedback and improvements from all Partners.
7.0.	ENSA Nantes All Partners	01.06.2023	The Chapter on Final Conference filled by ENSA Nantes, plus the report completed by all Partners and uploaded to TUL MS Teams (IO4 Leader).
8.0.	Lodz University of Technology (TUL)	**06.06.2023**	**Final version of the IO4 Report ready** and distributed to all Partners. **Data from North Macedonia is missing: nothing has been submitted since the first draft (03.05.2023); four syllabuses in German are missing from HCU**

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1 Introduction: a summary of the overall BIMaHEAD activities and results

1.1 IO1 in brief

The first output was benchmark state-of-the-art of BIM programs and courses implemented online or in a blended learning format. The aim was to do an analysis of good practices of current educational programs offered in the selected countries which supports our consortium in tailoring unique pedagogical programs. Each partner provided an in-depth overview of the existing BIM educational and training programs at national level and, additionally, in one another country. In total, 10 countries will be in focus (5 BIMaHEAD consortium countries and 5 additional). The Benchmarking analysis and good practices will give valuable recommendations for curriculum development in the BIMaHEAD project.

Activities in this IO were:

- Definition of the Research Methodology
- Desk research - Benchmarking analysis of existing digital programs and courses in BIM
- Analysis and writing the Report

The two main target groups were: students studying and enrolled in BIM programs/universities and academic staff teaching BIM courses at HEIs.

This IO analysis results and benchmarking reports with recommendations for curriculum development. The analytical assessment provides a complete and accurate illustration of the current situation and vision of digital readiness in higher education institutions regarding BIM. Project and associated partners took part in conducting the analysis.

IO1 has the following transferability potential: conclusions and recommendations can be used by other European HEIs striving to digitalise their programs. Additionally, the lessons learned from best practices can promote and enhance internationalisation in other institutions by introducing digital education.

The new context imposed by the Covid crise and the necessity to promptly find a solution to overcome the obstacles for face-to-face learning, the need to train the students to use and become familiar with the BIM tool in particular as, in general, to develop digital skills and abilities, and, in fine, to contribute to match the gap of specific digital competences expected on the construction/building labour market, are the main aspects that the needs analysis done by the project had highlighted. In this sense, BIMaHEAD will simultaneously bring a concrete answer of this complex issue and will strongly contribute for the digitalisation of the HEI, and especially through the fact that the BIMaHEAD e-course will be available for free including the report recommendation to facilitate its transfer and replicability.

1.2 IO2 in brief

Based on the outcomes from IO1, the information gathered was consolidated and reviewed. The chosen methodology was defined based on the partners' previous experience delivering (online) education and based on IO1. Subsequently, a pedagogical model was developed and used as a foundation for a tailored e-learning course, in this setting named as module. The result of this work package is a model describing a pedagogical approach and a scientific article providing the overall picture of the pedagogical approach. The output of the work package contains: the identification/selection of the methodological approach, a definition of learning objectives, a definition of assessment criteria and the development of the methodological framework.

A review was done regarding IO2 based on the result of IO1, and the most important conclusion of the review was a lack of online education and training on the topic of BIM. Furthermore, the conclusion was that when online education was provided, this was generally taught through traditional pedagogical methods and approaches.

The maturity and diffusion of BIM vary across Europe. In order to deliver a course on using BIM in the construction industry, which is usable in differing contextual settings, a new approach is needed. Public sector innovation focus on creating new societal values by, for example, improving or changing how education are delivered to citizens. By using new or novel new forms of knowledge diffusion an increase in societal value can be achieved as a form of public sector innovation. Such an approach does not necessarily entail the creation of new paradigm shifting pedagogical tools, however. New combinations of already established tools and methods may also increase diffusion of knowledge and thus be innovative.

In order to create a course, which increase diffusion of BIM in the construction industry across Europe, it is necessary to create an approach which allows for the identified difference in maturity and level of diffusion of BIM. In order to achieve this a number of prerequisites has been identified:

1. The course should be available online.
2. The course should be available for free.
3. The course should be adaptable to pan European local educational and training contexts.
4. The course should be able to be integrated into existing academic courses and into professional/vocational training.

The key motivation of completing an academic course, or professional training, can be divided into two categories, intrinsic and extrinsic motivation. Intrinsic motivation is driven by the individual's pursuit of knowledge to fulfil personal goals or to achieve professional proficiency. The individual's extrinsic motivation is propelled by the individual's need to display his or hers' proficiency for others. From a teaching perspective the intrinsic motivation is fulfilled by providing knowledge in a way that can be absorbed by the individual. Extrinsic motivation is traditionally satisfied by providing degrees/diplomas by universities, or certificates of completion by professional trainers. Given the requirements for this project the traditional way of satisfying the extrinsic motivation of learners is not possible. While certificates are indeed included in the course developed within the BIMaHEAD project, the certificates' value is questionable since the modules are meant to be changed and/or adapted to national context, and already existing courses and programmes. As a consequence, the goal of the BIMaHEAD project is to boost intrinsic motivation factors. It should be noted though that extrinsic motivation factors may be created by educational institutions adopting the BIMaHEAD course independently of the BIMaHEAD course design.

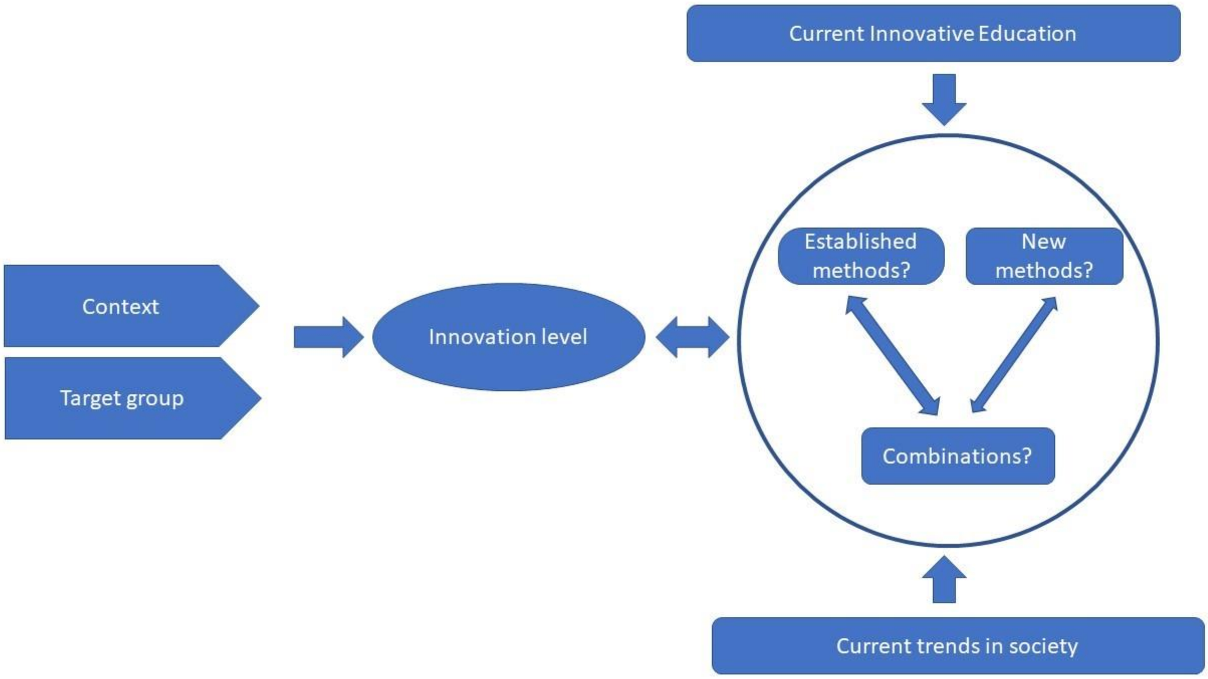

Fig. 1.2.1 Description of the innovation framework

The above figure describes the innovation framework. As described above, innovation is defined by the context for the target group. The innovation level will be different depending on the context, but also depending on the implementation of pedagogical methods. The implementation of pedagogical methods will in turn depend on current trends in society in large, and on current developments in pedagogical methods in general.

The operationalisation of the considerations above has resulted in the adoption of a gamification approach for the BIMaHEAD modules. By providing small incentives to move forward in the module, while providing learning opportunities with each trainee interaction with the module material the intention is build a momentum leading to trainee retention. The modules are to be used simultaneously with traditional modules; they are additive and integrational and have an open platform. The simultaneousness and integrational characteristics mean that the modules work with other courses and form a basis for regular courses. For example, a module can introduce the learners to an area/theme. A course can then add material in a course based on these themes and the needs of the national context.

The innovativeness of each module is respectively the following:

Nantes: The leading innovative element in this module is the use of virtual reality. The module introduces a novel design process by suggesting a methodology that includes data collection and designing intricate shapes while considering climate constraints. The resulting designs are then evaluated in virtual reality on a communal Metaverse platform, allowing for a seamless transition from design to project communication. This innovative design paradigm focuses on exploring a range of solutions that meet various constraints through the use of algorithmic and generative design methods. The integration of virtual reality introduces new avenues for evaluating project results and facilitating communication.

Hamburg The innovative elements of this module are, on the one hand, the VR game environment, which we use to impart knowledge. It enables learning by doing on a virtual construction site where participants have to assemble virtual components correctly. The VR environment provides a real-life connection to real construction sites that most architecture students lack today. The participants have to interact in virtual spaces, make mistakes from which they learn and thus have a sense of achievement at the end when the component has been assembled correctly. This learning through interaction is the second innovative aspect of the module.

Lodz: The main innovative element in this module is the innovative user interface in the form of a virtual world explored by a student-directed character. There is a three-dimensional model that is used in which users observe a world depicted from the back of a guided character and by moving around the theory of clash detection is explored in the form of a computer game. There are also instructive interactive videos that support the learning process.

IECE Skopje, North Macedonia: The main innovative element here are narrative videos supported by web-based tutorials, links for Guided self- learning, a new combinations of teaching methods are the main innovative issue here. Guidelines for use of sets of tools for energy analysis of buildings and Case studies this needs to be developed in terms of what is innovative – Hello, Partner from Skopje, please complete this!!

Halmstad: Gamification significantly influences the frame of reference/model. In the Halmstad module, the leading innovative element is a so-called educational quiz, which means that the learner is guided through pre-recorded lectures and demonstrations by a series of quizzes. These quizzes are constructed by questions which are constructed to give immediate correct/incorrect responses with attached feedback to the trainee. Both a correct and an incorrect answer will provide a learning opportunity in terms of a short educational text, thus providing incentives to continue towards the next question and the next lecture. Each completed lecture and adjoining quiz will result of a small gratification in the form of a badge. Upon completing all badges available a certificate will be provided.

Conclusion of all modules

Upon completion of all modules an initial comprehensive view on digitalization and digital tools is available. There is a mixture of innovative set-ups and approaches that are used. Reviewing the modules altogether learners are provided a palette of opportunities for learning and forming a basis for continued development of education in digital tools within EU.

1.3 IO3 in brief

As a direct follow up to the IO2, the IO3 was meant to develop the e-learning content based on the learning objectives and pedagogical approach defined in IO1 and detailed in IO2.

Thus, while continuously matching the IO2 due to students and teachers' feedback, the goal was to draw the edges of the form that the new online educational content would take in a general way and for each module according to its own objectives, following a defined methodology and environment:

- Preparation/adaption of the content of the e-learning modules.
- Implementation and testing of the prototype of BIMaHEAD online course on different platforms;
- Internal feedback – from students and teachers;
- Optimisation and final version of the BIMaHEAD e-learning course and modules;
- Organising 5 multi-stakeholder's workshops.

1.4 IO4 in brief

The last intellectual Output of the BIMaHEAD Project was meant to gather, compare, and summarize all results. It was followed by SWOT analysis as well as each Partner reflections. What is more, conclusions and guidelines for future development of e-learning courses were drawn. This report is the final effect of the Project and was elaborated under IO4 work package. At the end of the document all syllabuses translated into five languages are attached. The course website is as follows: https://www.bimahead.eu/

2 Description of the developed BIMaHEAD e-course

The BIMaHEAD Project, carried out by five institutions from France, Germany, Sweden, North Macedonia, and Poland has been directed to all those interested in gaining practical training and raising their specialist competences, mainly to architects, designers and engineers engaged in the construction industry, as well as students majoring in these fields. The BIMaHEAD Project Partners have developed five e-learning Modules addressing the following topics:

- **BIM Form Finding from Environmental Constraints** (developed by ENSA Nantes, France)
- **BIM Modelling** (developed by HCU Hamburg, Germany)
- **Clash Detection** (developed by TUL Lodz, Poland)
- **Digital Calculation** (developed by HH Halmstad, Sweden)
- **BIM Energy Calculation and Evaluation** (developed by IECE Skopje, North Macedonia)

2.1 ENSA Nantes, France

The "form finding" Module focus on using environmental elements as inspiration for designing shapes, and it starts with the software Grasshopper, which allows designers to create complex shapes and structures through visual programming. The Module then moves on to using Unity and metaverses to create a virtual experience of the design proposals. Unity is a game engine that enables designers to create interactive and immersive experiences. By using Unity, students can create a virtual environment where users can experience the design proposals at a 1:1 scale, allowing users to experience the proposed design in a more realistic and interactive way, making it easier to visualize the final product.

The uniqueness of the Module comes from 3 main features:

- It is a comprehensive guide to understanding the keys to parametric modelling, covering everything from the simplest basics to complex models incorporating external variables.
- The Module does not only deal with parametric modelling but uses it to address more advanced issues such as the study of insolation.
- The Module is intended to allow the experience and modification in real time of the models you create in VR.

The Module is almost completely developed, but we are still experimenting and trying to find the best way to link parametric design and virtual reality.

The Module structure is the following:

- Grasshopper basics
- Grasshopper – Parametric Structure
- MonteCarlo, Galapagos – Complex surface calculation
- Ladybug – Solar panels

- Express - Railings
- Express, Kangaroo – Circus tent
- Express – Shutter
- VR integration - Unity
- VR integration - Blender

The Module is almost completely independent from a physically assisting teacher, it is designed so that you can take the whole course by yourself without prerequisites but takes all its meaning when done in a group with a tutor who can truly accompany you through the whole thinking process.

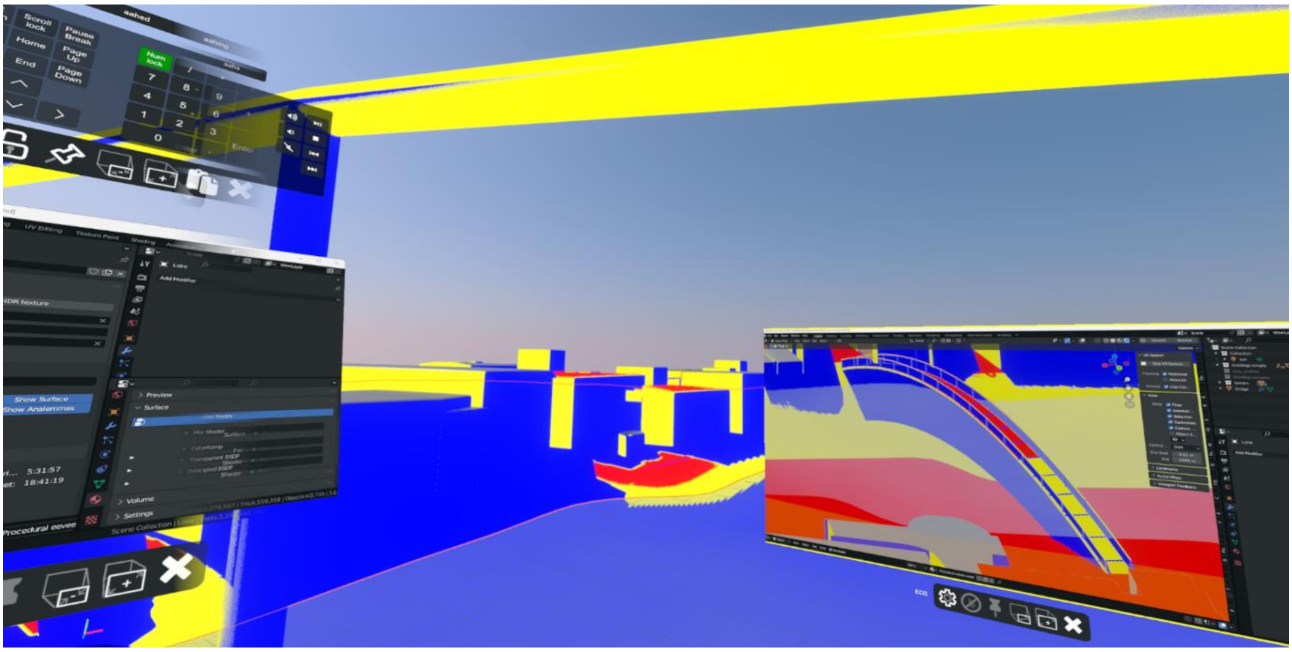

Fig. 2.1.1 A screenshot from the HMD view: the blender scene made with the tutorial and editable in VR

Fig. 2.1.2 A screenshot of a world created in spatial within the frame of BIMaHEAD courses/workshops

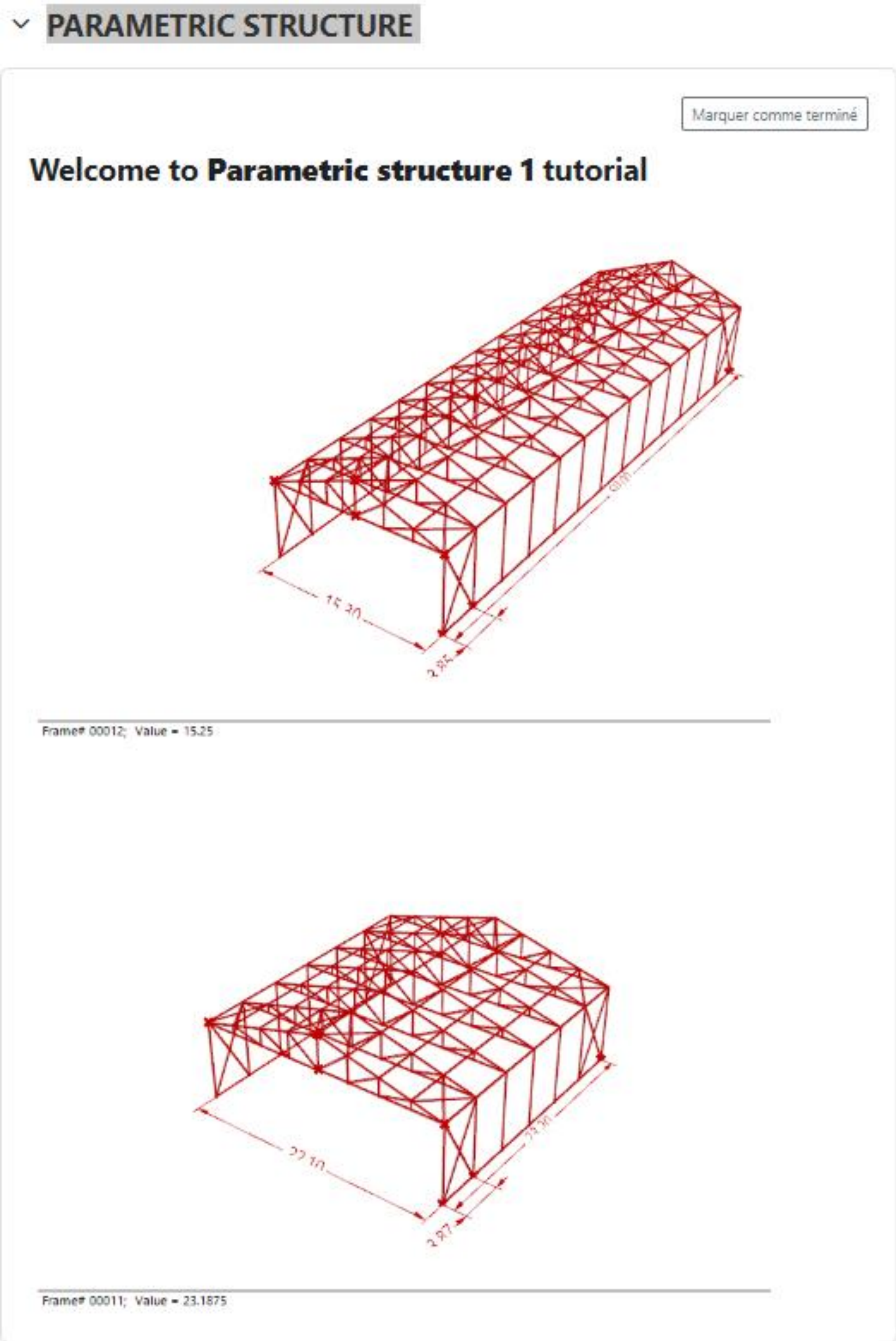

Fig. 2.1.3 A screenshot of a course displayed on Moodle

2.2 HCU Hamburg, Germany

Module - summary

The module BIMaHEAD-Construction 1 is a digital learning module on a Moodle platform, which consists of 5 consecutive exercises. In linked virtual rooms, the participants assemble constructive components from virtual building materials. They learn how buildings are constructed and designed in the real world and how they are modelled in BIM as a digital twin. Afterwards, the participants model their own 3D model with CAD software, put it to a peer assessment and evaluate the models of the other participants.

Module uniqueness

- Gaming: The individual exercises are structured as games in which the participants gain knowledge through experimental action.
- Self-learning: The participants build the components from the virtual exercises on their own. To do this, they use the linked tutorials of the respective software manufacturers. In the forum and subsequent peer assessment, participants help each other and network.
- Virtual rooms: The spatial representation in virtual rooms makes it possible to recreate real construction processes as on construction sites. This closes the gap of missing construction site practices during Corona and permanently brings a strong reference to reality into the modules.

Stages of the Module development

The virtual rooms are ready for use and have been tested and evaluated in several test runs by participants from outside the project. The peer assessments only work with a high number of participants and can only be tested and improved after the relaunch of the module.

Structure of the Module

The module is divided into 5 exercises, which are all structured in the same way:

1. Presentation of the task and the component to be built.
2. Assembling the components in virtual spaces, difference between real construction and digital twin.
3. Rebuilding the building component as a 3D model (digital Twin) with own means, help from tutorials from software manufacturers.
4. Mutual evaluation of the submitted models in peer assessment, recognition of one's own progress, networking, and mutual help among each other.

A description of the independence of the Module from the physically assisting teacher

The module functions autonomously, without simultaneous support from physical teachers. The participants help each other. The responsible teachers only monitor the peer assessment process or intervene in case of dysfunctions.

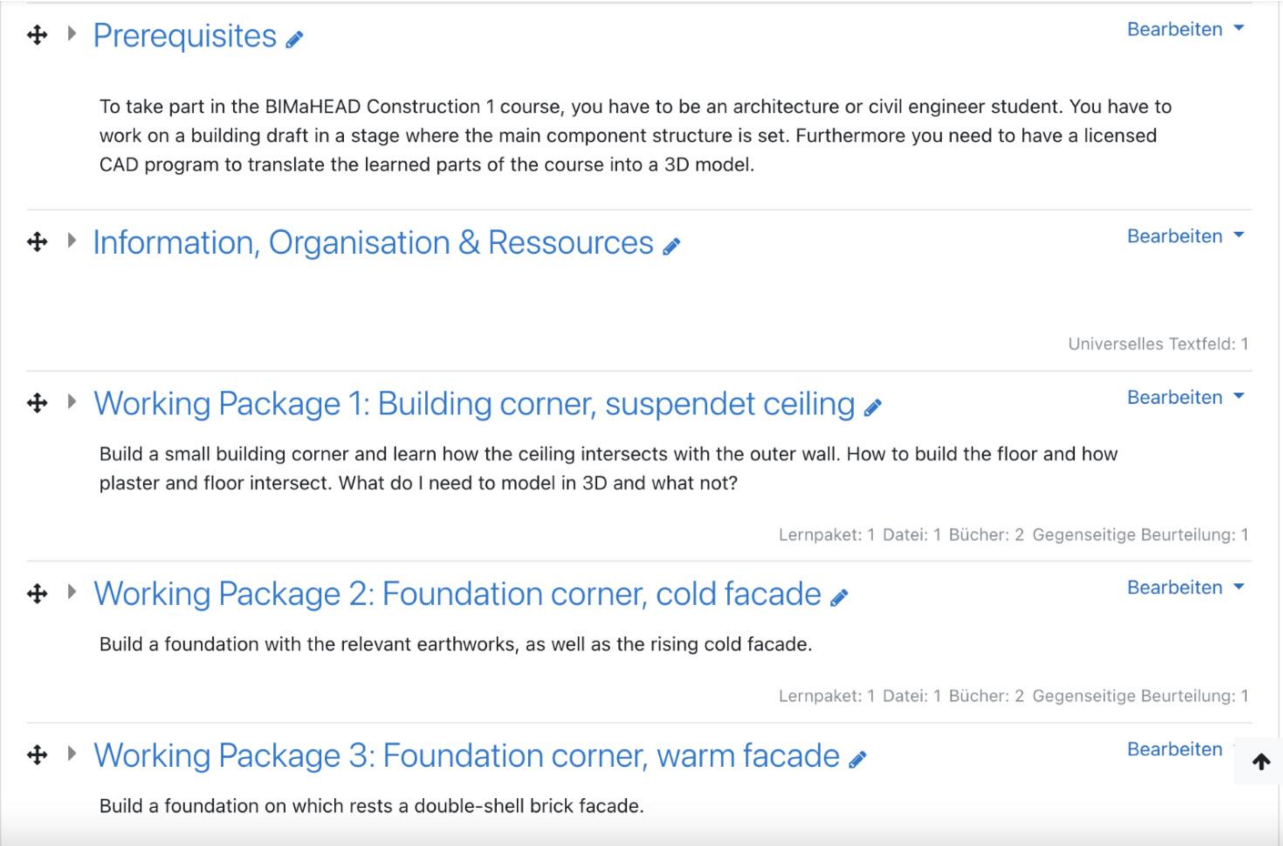

Fig. 2.2.1 Moodle page with working packages (extract)

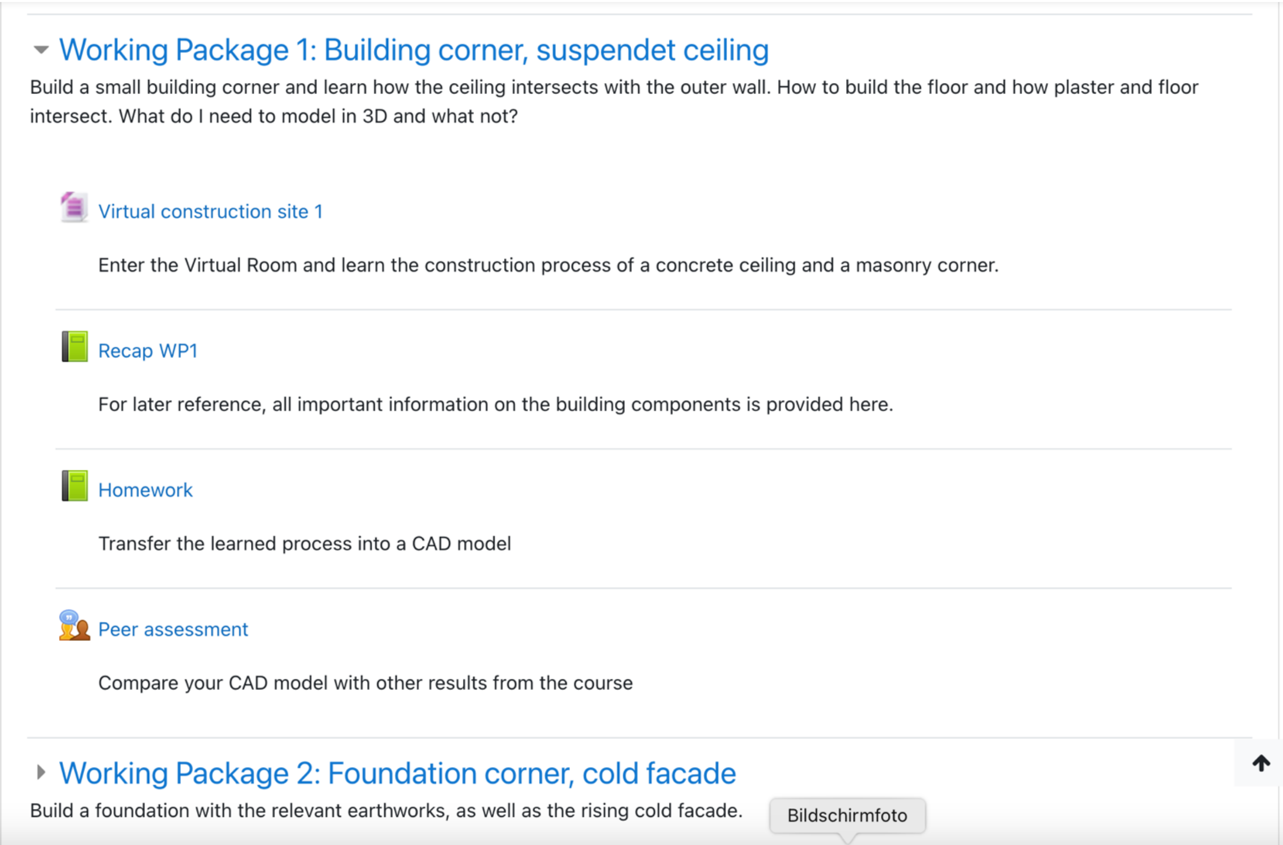

Fig. 2.2.2 Exemplary working package within Moodle page

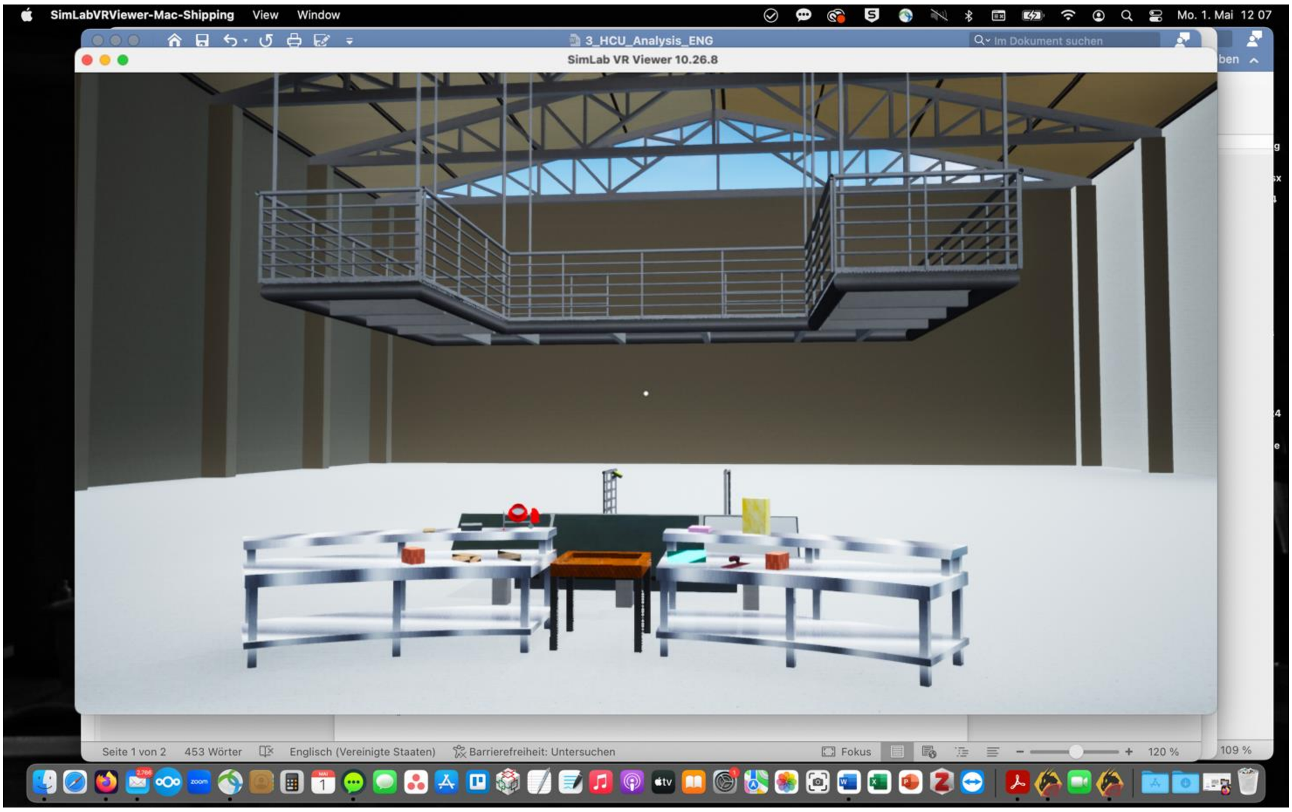

Fig. 2.2.3 Virtual Construction site: Initial Scene

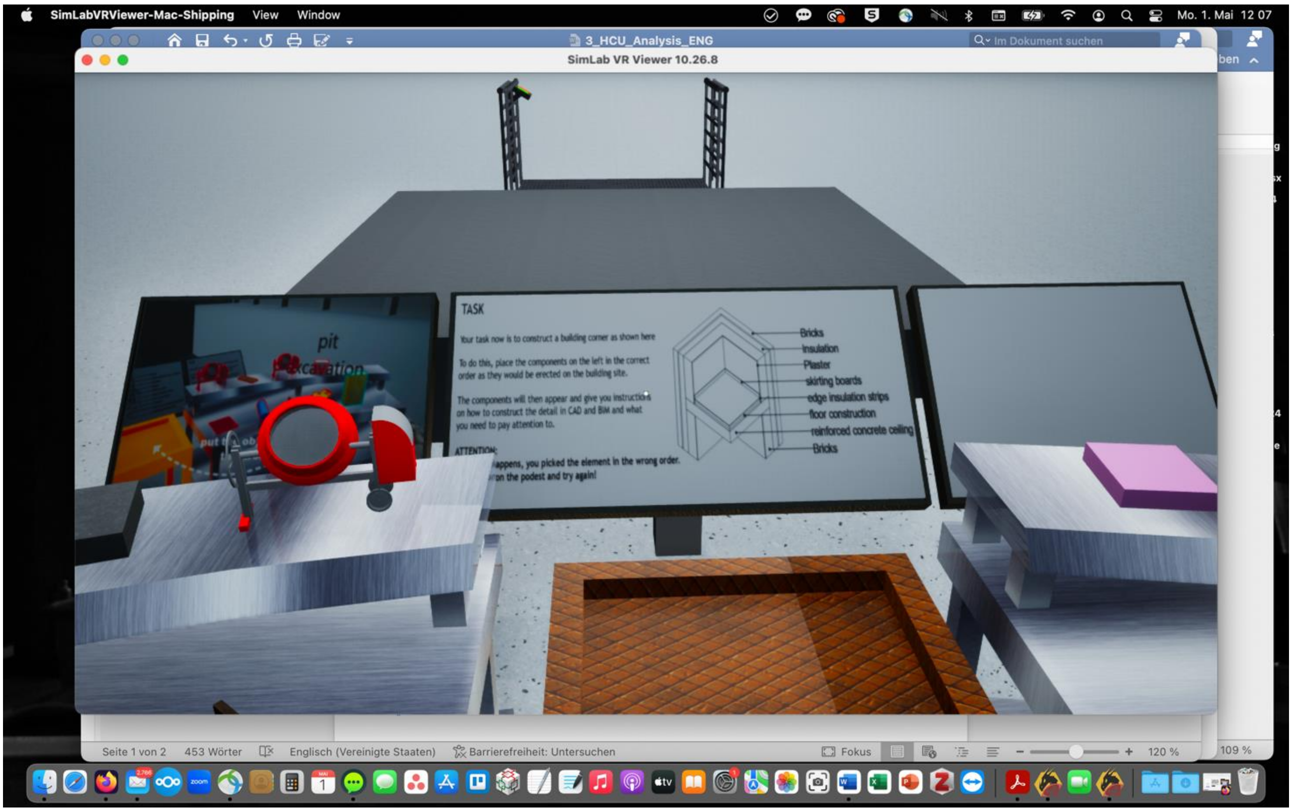

Fig. 2.2.4 Virtual Construction site: Instructions

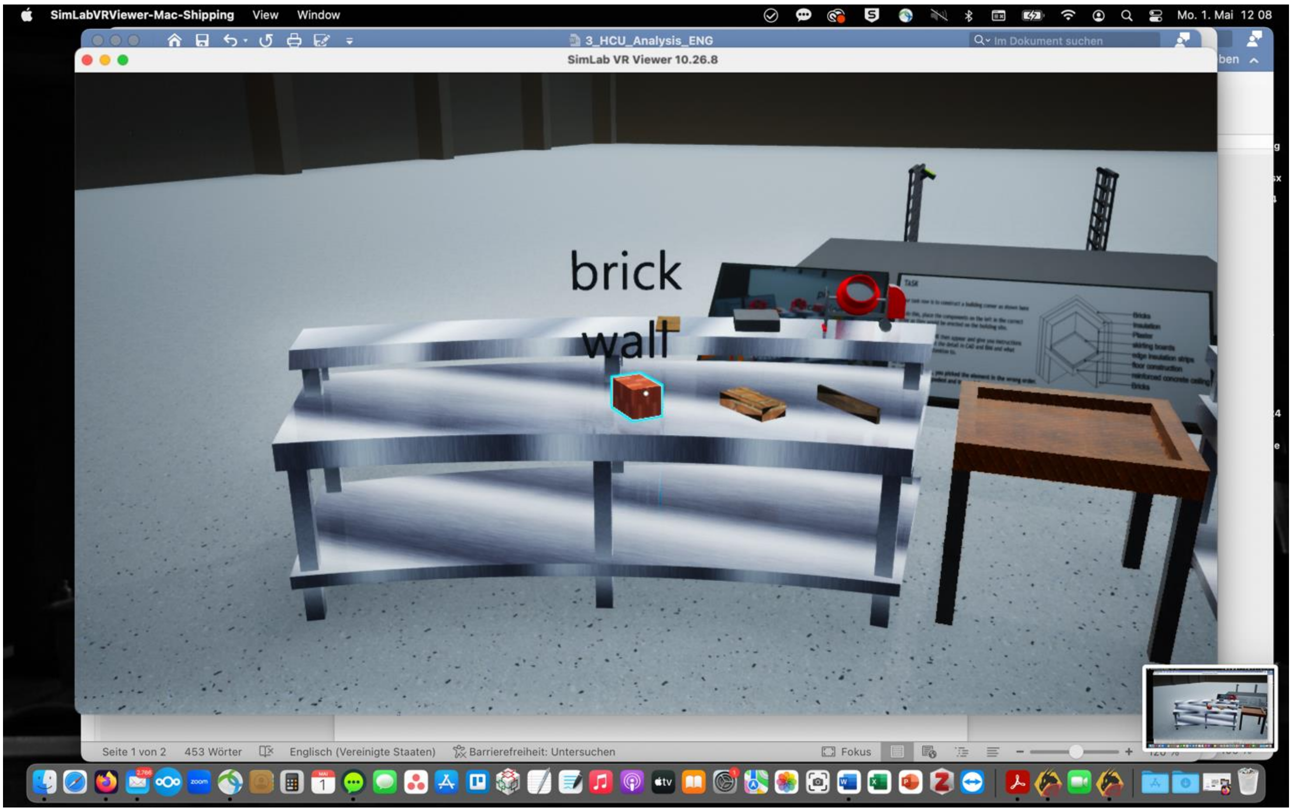

Fig. 2.2.5 Virtual Construction site: material grabbing

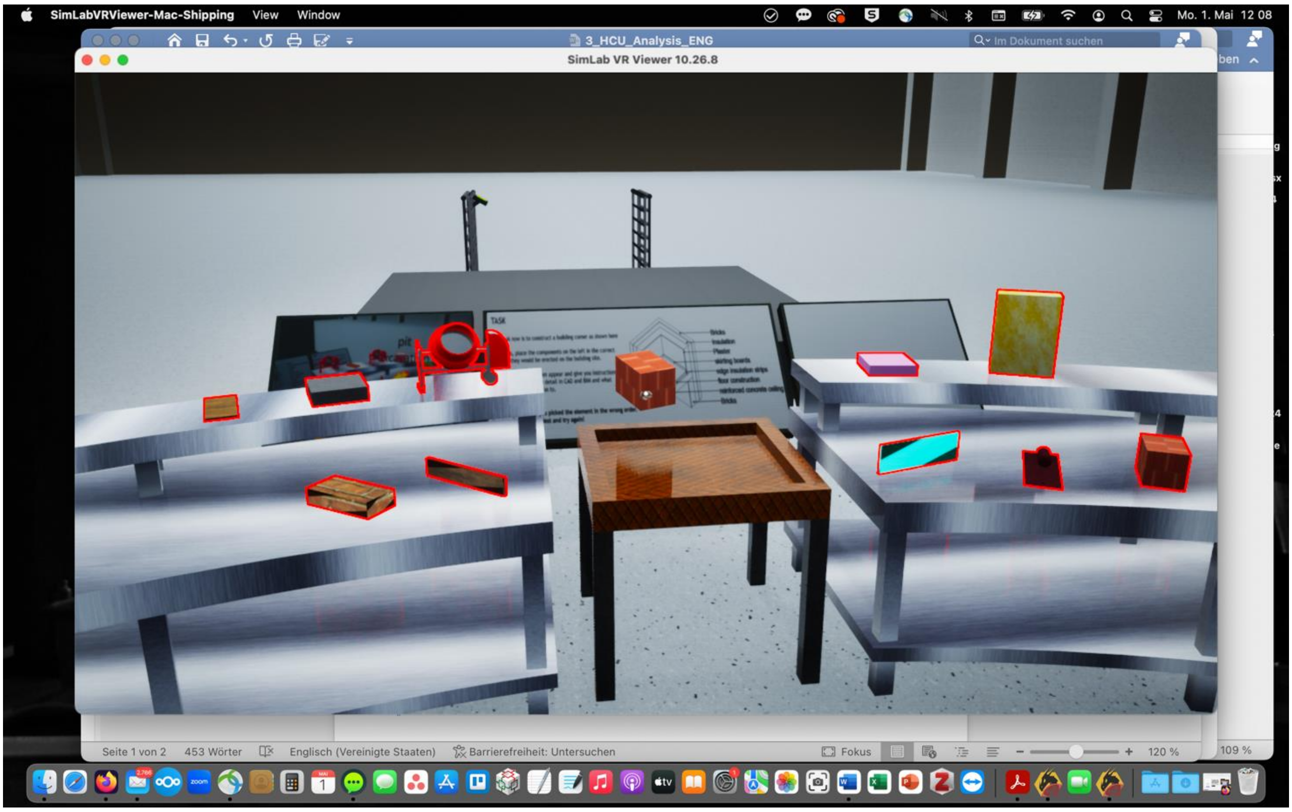

Fig. 2.2.6 Virtual Construction site: Material positioning on table

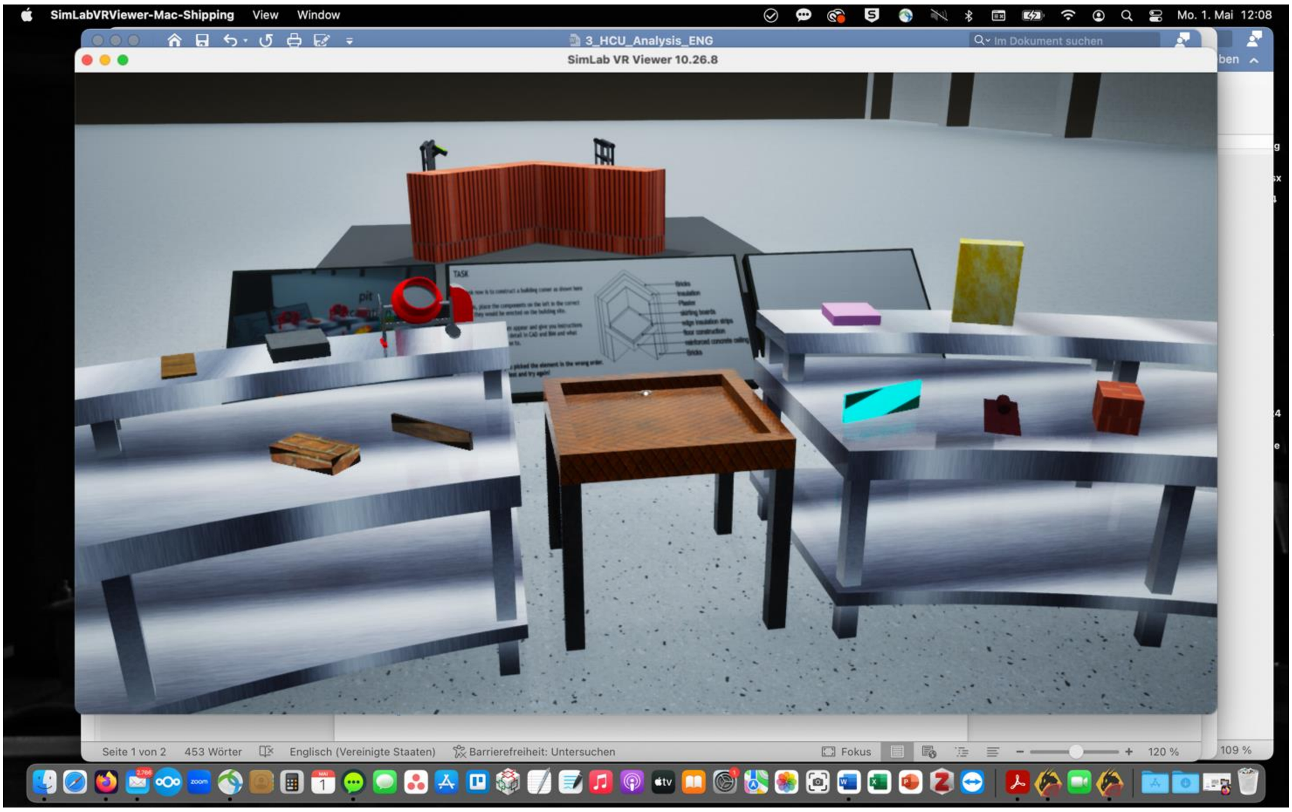

Fig. 2.2.7 Virtual Construction site: Appearance of the component on virtual construction site

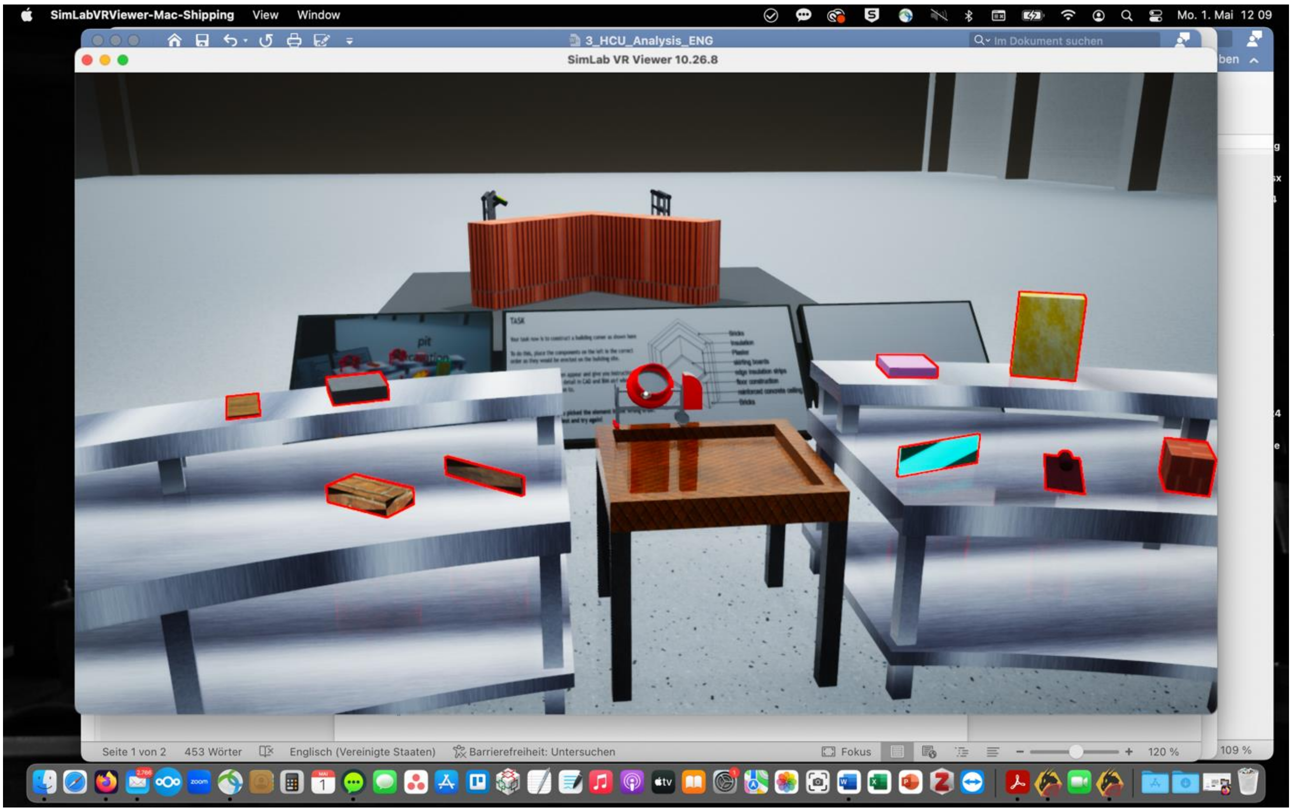

Fig. 2.2.8 Virtual Construction site: Material selection concrete, positioning on the table

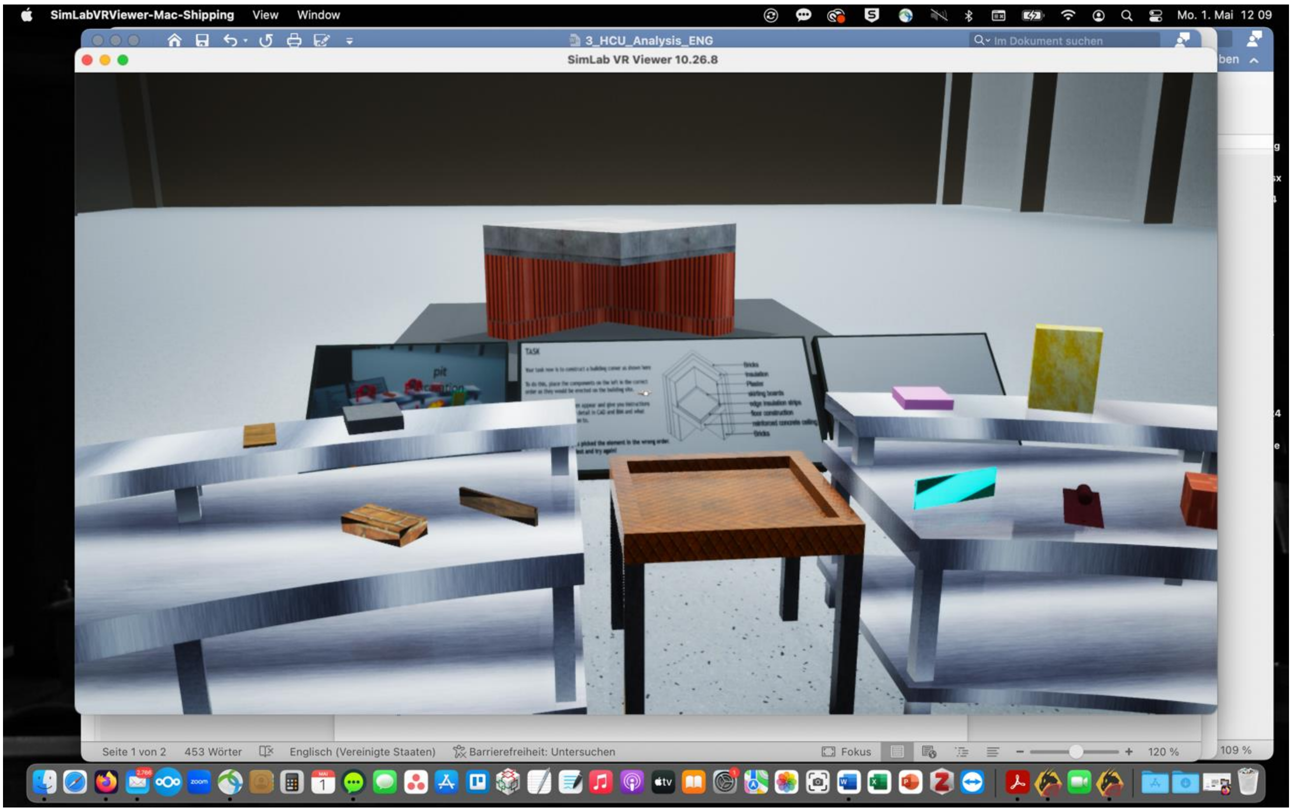

Fig. 2.2.9 Virtual Construction site: Concrete ceiling appears on virtual construction site

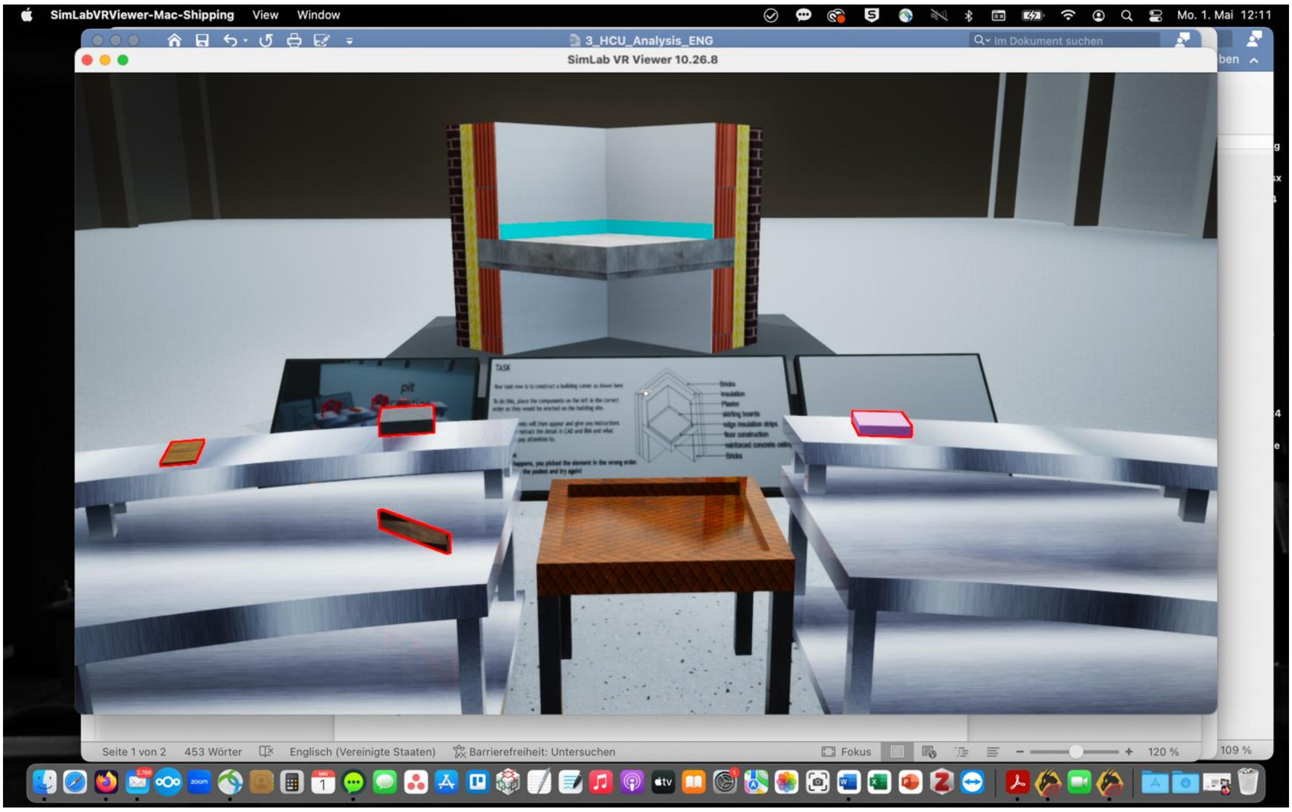

Fig. 2.2.10 Virtual Construction site: Building corner with exterior wall construction and interior fittings

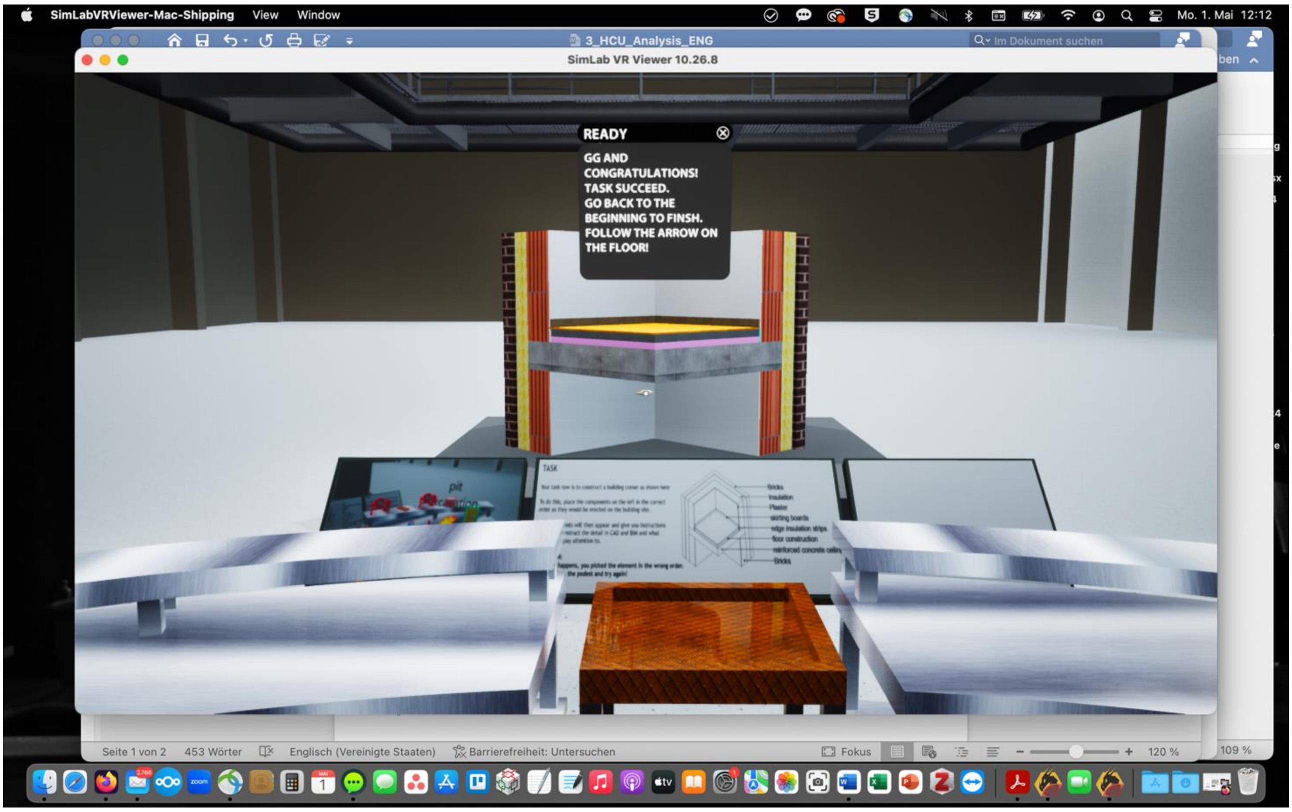

Fig. 2.2.11 Virtual Construction site: Finished building corner, successful completion of exercise

2.3 HH Halmstad, Sweden

The digital calculation module supplied by HH revolves around reviewing and elaborating on the digital calculation process in construction. The objective and goal are to provide fundamental knowledge of digital calculation in its context. It contains a learning and assessment stage. However, software needs licensing; thus, it is required to demonstrate the software without necessarily buying access to a particular software. The learning stage consists of a *Review of the digital construction process and its advantages, The tender and calculation process, The digital tender and calculation process* and a final lecture about *Procurement.* The first part of the module is examined through a multiple-choice quiz, which is mandatory to proceed to the second part of the module.

Based on the first part of the module, the learners are provided with demonstrations of typical software alternatives showing how calculations and estimations are conducted in practice and what features that are available.

The demonstrations are followed by an educational quiz where each question provides a learning opportunity to enhance the learning experience further. The assessment part of the module contains material from the demonstrated software and provides the possibility to assess the outputs produced by the software. This enables the trainees to identify typical problems that can arise when using software-based tools. When all steps in the module have been completed a module certificate is provided.

The demonstrations also show how climate impact is automatically shown in the calculations and provides data to assess, not only direct costs but also climate impact from different solutions.

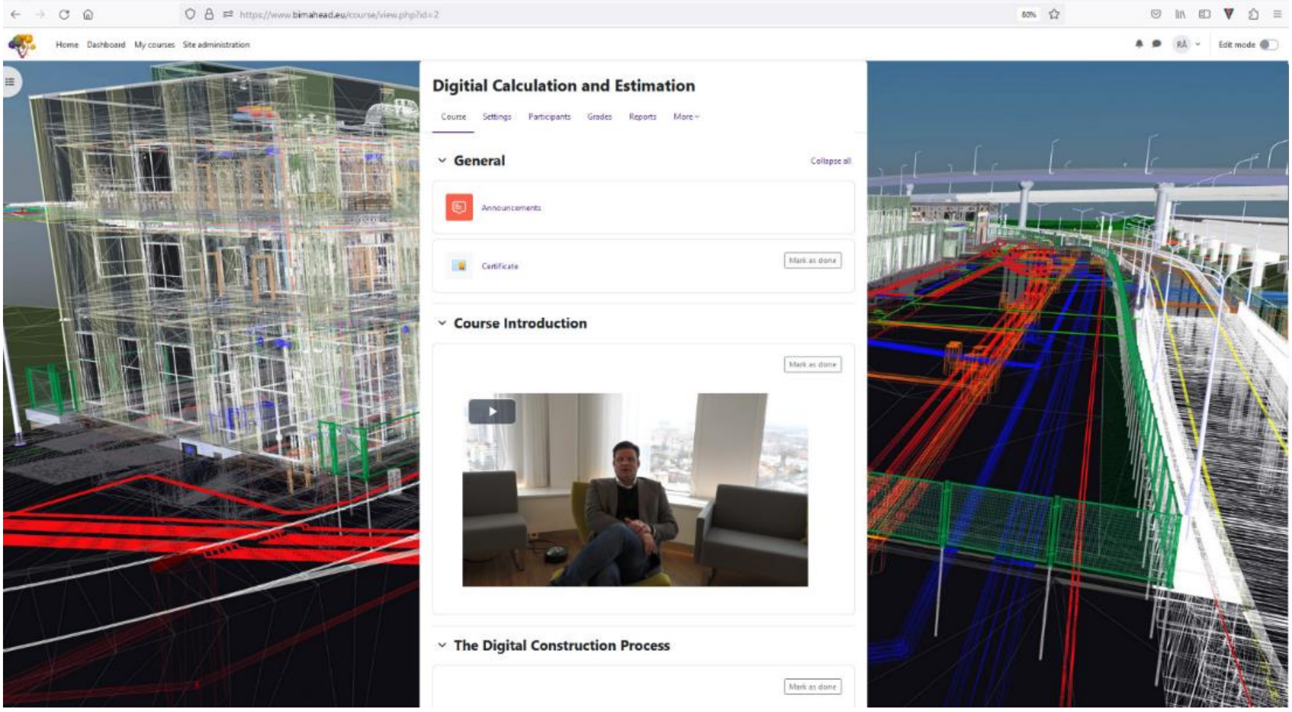

Fig. 2.3.1 Example - Course introduction view

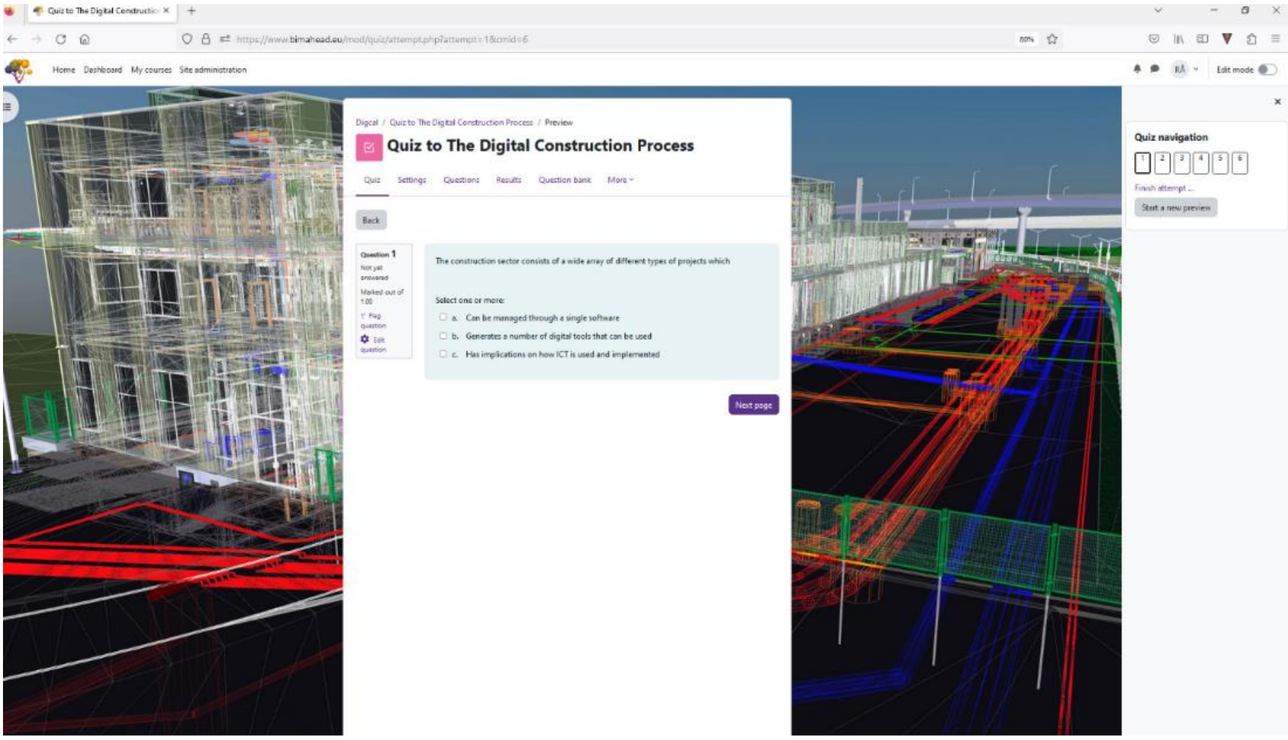

Fig. 2.3.2 Example - Quiz for online lectures

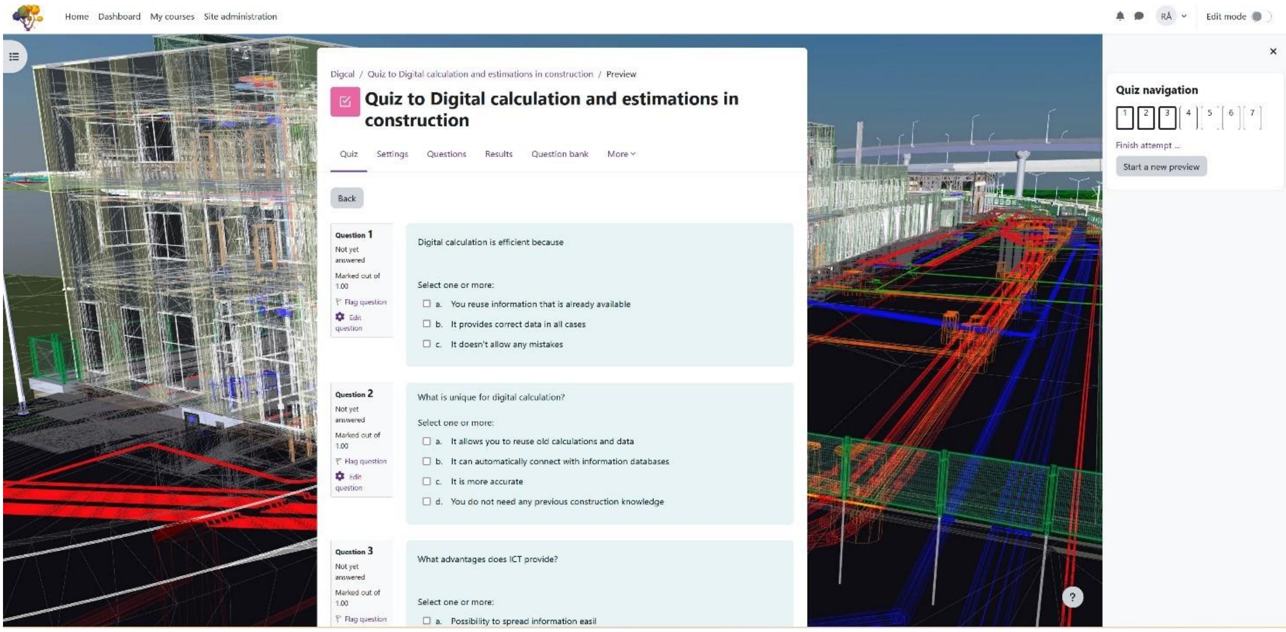

Fig. 2.3.3 Example - Quiz for online lectures

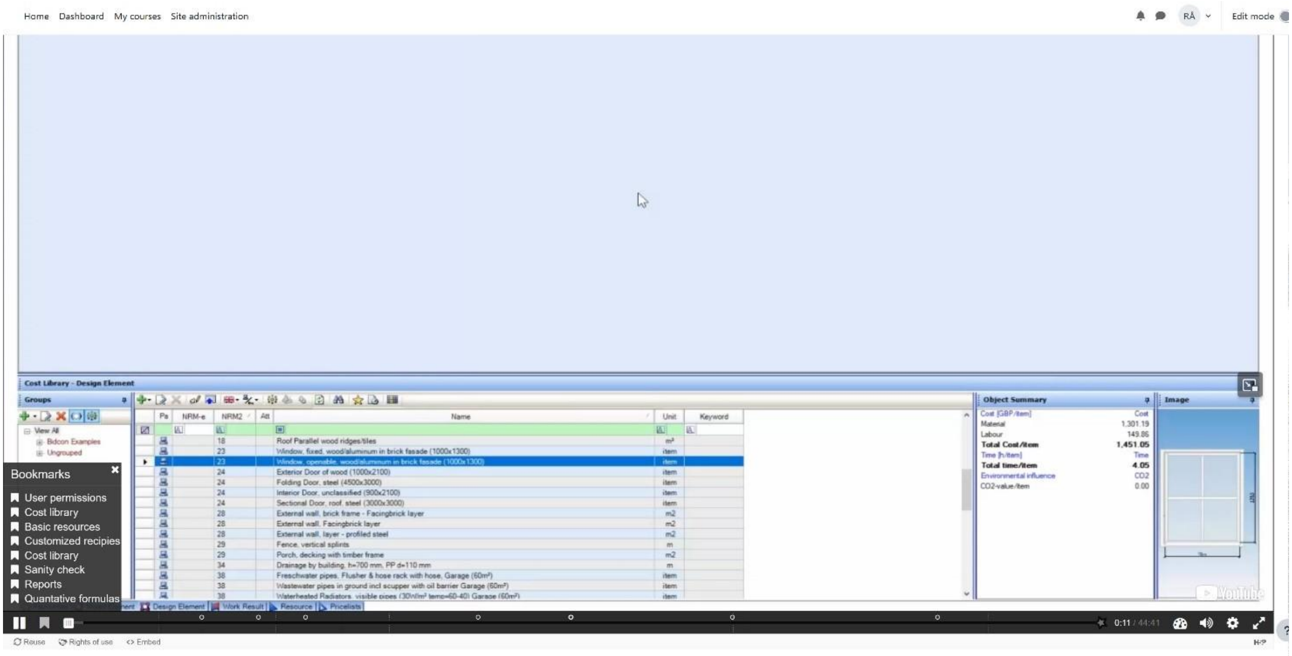

Fig. 2.3.4 Example - Online software tutorial

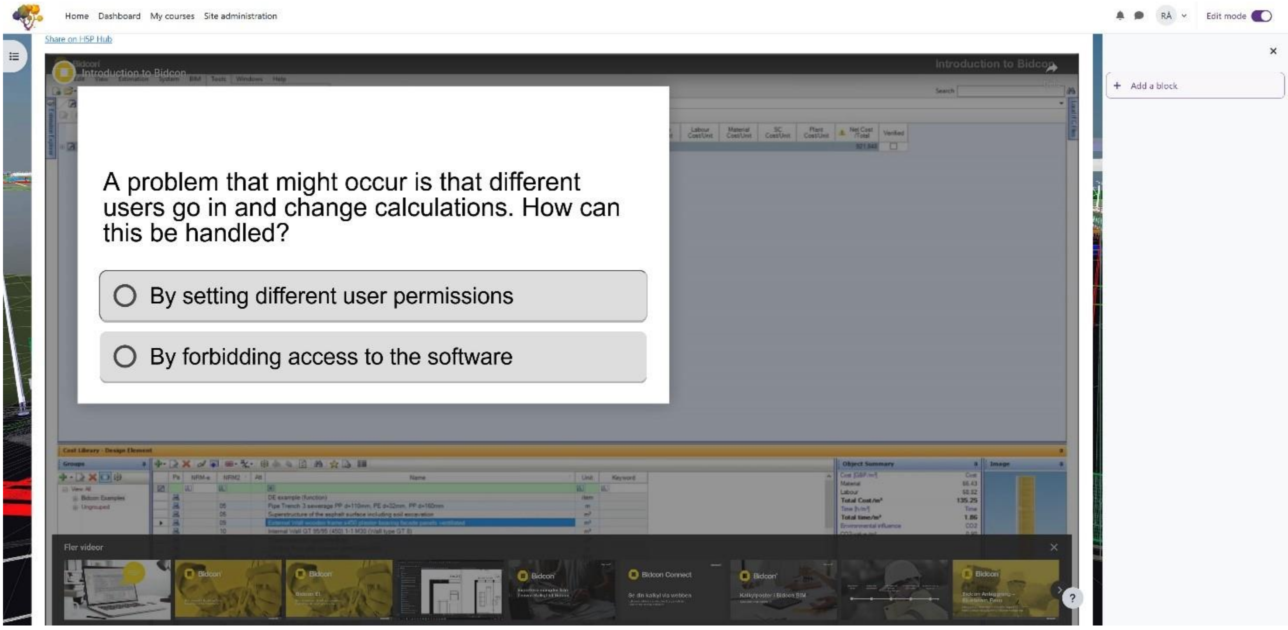

Fig. 2.3.5 Example - Quiz integrated into online software tutorials

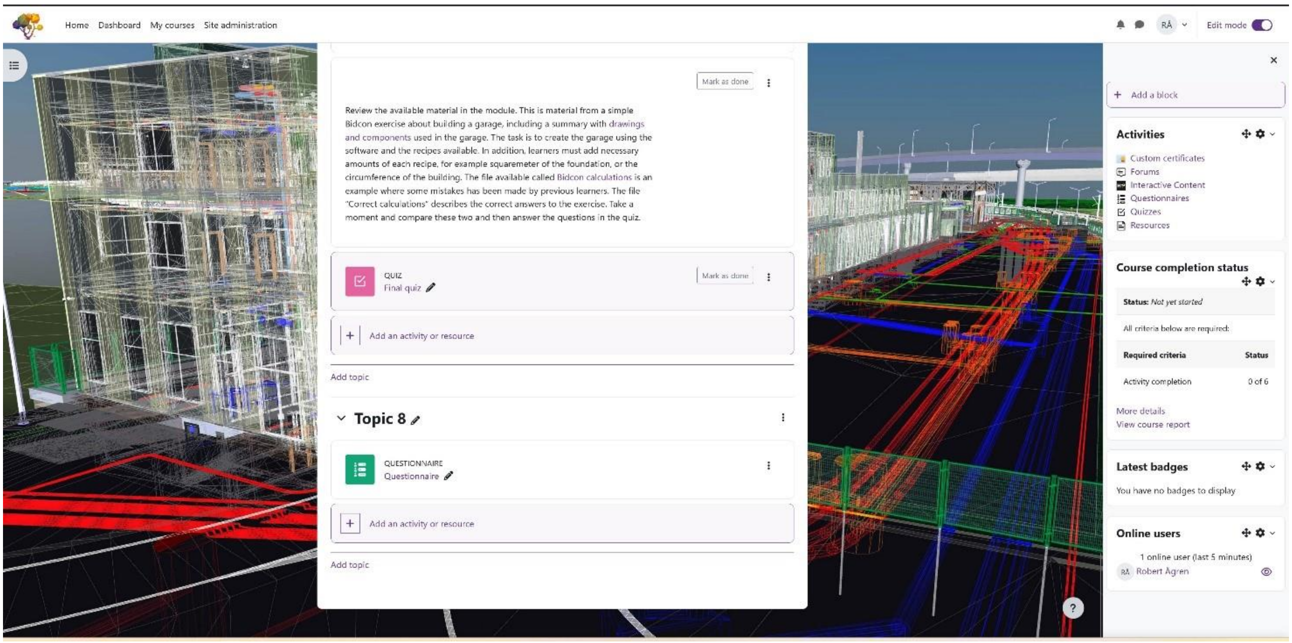

Fig. 2.3.6 Example - Student view for final quiz and course evaluation questionnaire

2.4 IECE Skopje, North Macedonia

Module – summary

The module is intended to provide students with advanced knowledge on use of BIM as a digital tool to improve energy efficiency of buildings throughout their life cycle. Students will be introduced with concepts of energy consumption in buildings and energy and cost life cycle assessment. Basic definitions associated to energy values and variables are included in this module. Also, will be provided definitions and explanations of basic classification of energy efficient buildings, based on European commonly used codes.

The module explains the workflow of development of a Building Energy Model and carrying out of energy analysis by using BIM 3D model and appropriate plug-in software tools for energy calculation and of calculation of amount of energy required for heating of building spaces. This kind of energy is the largest portion (55% to 60%) in total operational energy consumption. Therefore, optimization of heating energy performance has the greatest impact on overall energy consumption of a building.

This module is based on an architectural 3D BIM model that has been developed previously, in Revit (Autodesk).

Calculation of required energy for building operation was carried out by software tools compatible to the software used for architectural model, Insight and Green Building Studio (Autodesk).

To follow the learning material and to do tasks requested in particular points, the learners are asked to download (for education purposes) the applied software, on the link below:

https://www.autodesk.com/education/free-software/revit

Module uniqueness

The **uniqueness** of this module is presentation of a generic workflow of development of a building, energy model, including guides for steps and checkpoints, to ensure correspondence to architectural model and basis for optimization of design alternative, replicable in other BIM software environments.

The modules were developed in several stages:

1. Development of theoretical part
2. Development of a 3D BIM architectural model (In Autodesk Revit)
3. Development of an energy module (in Autodesk 360 insight)
4. Development of learning materials (presentations, links for guided self-learning, course books)
5. Development of assessment materials
6. Uploading of learning and assessment materials to the Moodle
7. Testing of learning and assessment materials
8. Putting the modules in operation

Structure of the Module

- Content
  - Lecture 1 - Use of BIM Tools for Improvement of Energy Performance
  - Lecture 2 - Development of Energy Analytical Model
- Assessment
  - Quiz (It contains questions related to the learning content, a multiple-choice question, as a method of assessment)

The modules were created to be delivered completely on – line, including both the learning and assessment stage, without the need for physical assistance by a lecturer.

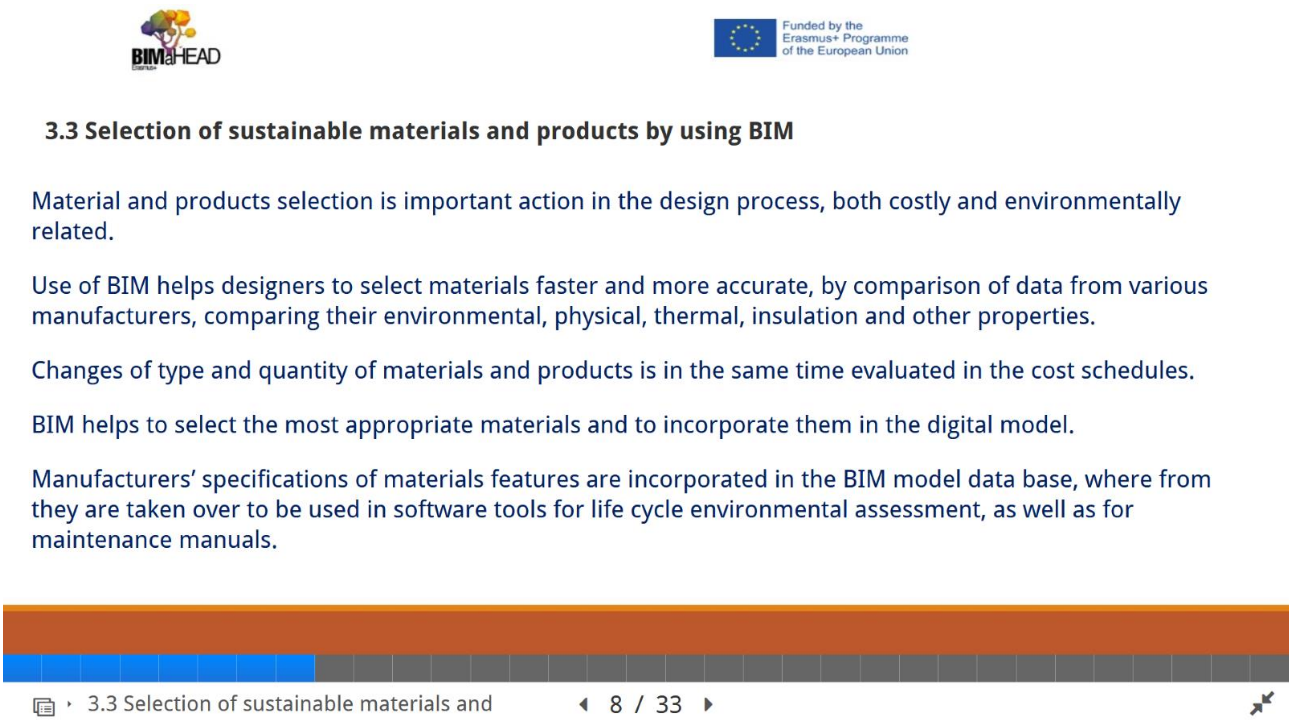

Fig. 2.4.1

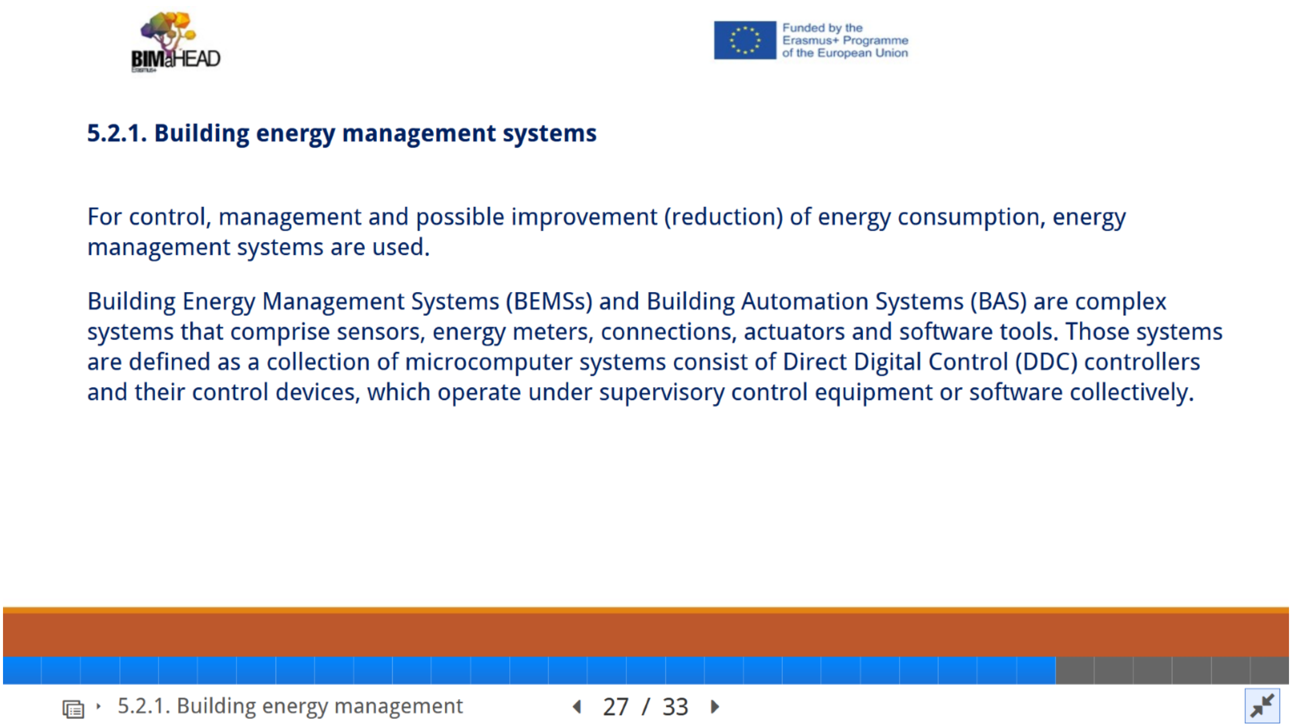

Fig. 2.4.2

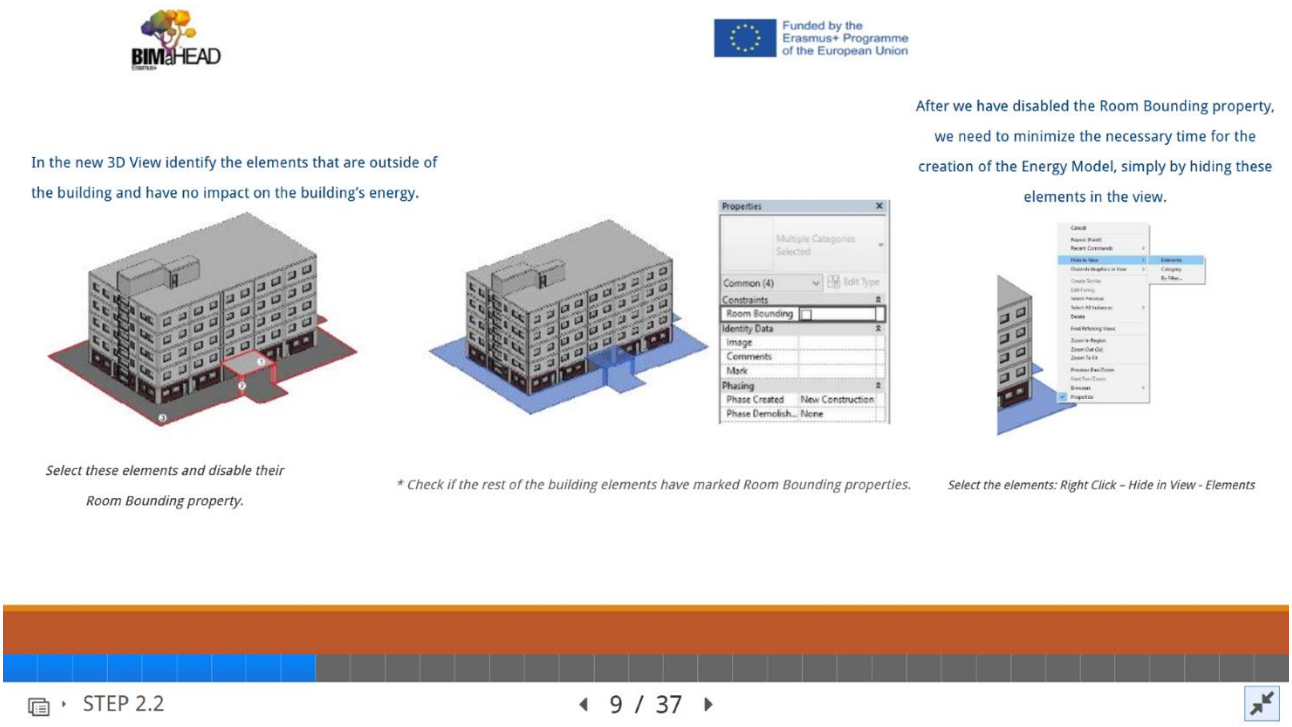

Fig. 2.4.3

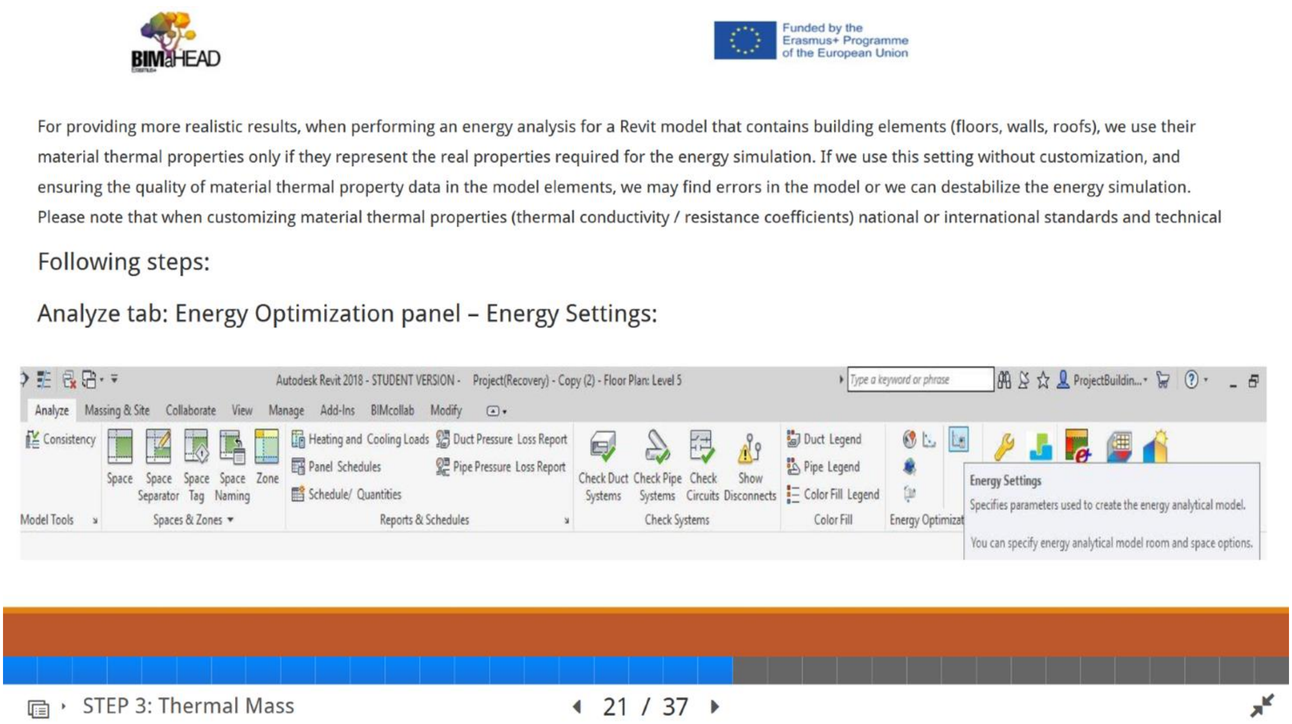

Fig. 2.4.4

2.5 TUL Lodz, Poland

BIMaHEAD Partner from Lodz University of Technology, Poland, developed a Module focused on detecting collisions in a virtual digital model of a building. Therefore, the name of the Module is Clash Detection.

Module summary:

The Module provides students with advanced knowledge and skills in Building Information Modelling (BIM) that is dedicated to detecting clashes and collisions in AEC projects. By detecting errors in projects at the early stage of design, engineers save resources, materials, costs, and time and by that, they contribute to a more sustainable built environment. The Module introduces theory and practices through sequences of tasks to gain skills needed for future architects and engineers in the AEC sector.

Module uniqueness:

The uniqueness of the Module is based on three main features:

1. The pedagogical method: it is designed to lead a learner through a game with levels to be achieved and scores to be collected. Successful completion of the Module may be rewarded with a certificate. Such method is not common in higher education learning environment, and what is more, it addresses the needs, and the way young generation acquires knowledge and skills most efficiently.
2. The independence of the Module from the physically assisting teacher. Besides, learning by doing and self-assessment are the key elements of the Module.
3. The uniqueness is visible also in the content which offers only useful real-based knowledge and carefully designed practical exercises.

Stages of the Module development:

The first sketches of the Module were developed with the use of selected software dedicated to clash detection issues. Evaluation of the effectiveness of software allowed to choose the best solutions and apply them in the Module. The lessons were designed as game levels to achieve, and all was tested on Moodle as the most common environment for teaching and learning in HE in Europe. The Module design stage was followed by testing phase. Then, feedback received from participants in the form of questionnaires was analysed and the Module content as well as user experience was improved and developed. The final result was presented at the National Workshop and gained positive feedback from the audience.

Structure of the Module:

The Module starts with a brief introduction to the content and prerequisites required to take the Module. Then, the following parts go as follows:

- Prologue: Truth or Dare?
- CHAPTER 01: Some troubles? Let’s solve them!
- CHAPTER 02: Keep calm and check everything
- CHAPTER 03: Take-off without counting
- CHAPTER 04: ArchiCAN or ArchiCAN'T?
- Epilogue: Soft landing

At the end, the Continuative BIMaHEAD Modules are proposed to link all BIMaHEAD Modules.

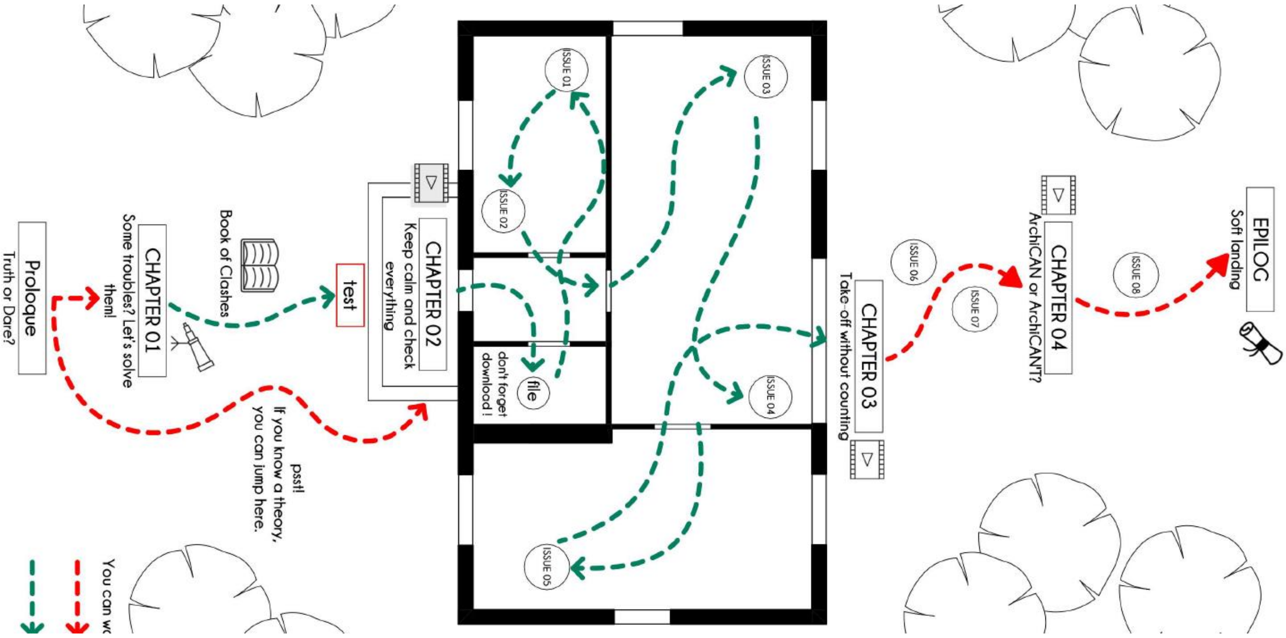

Fig. 2.5.1 A map showing the paths through the game learning experience

Fig. 2.5.2 A screenshot from CHAPTER 02: Keep calm and check everything

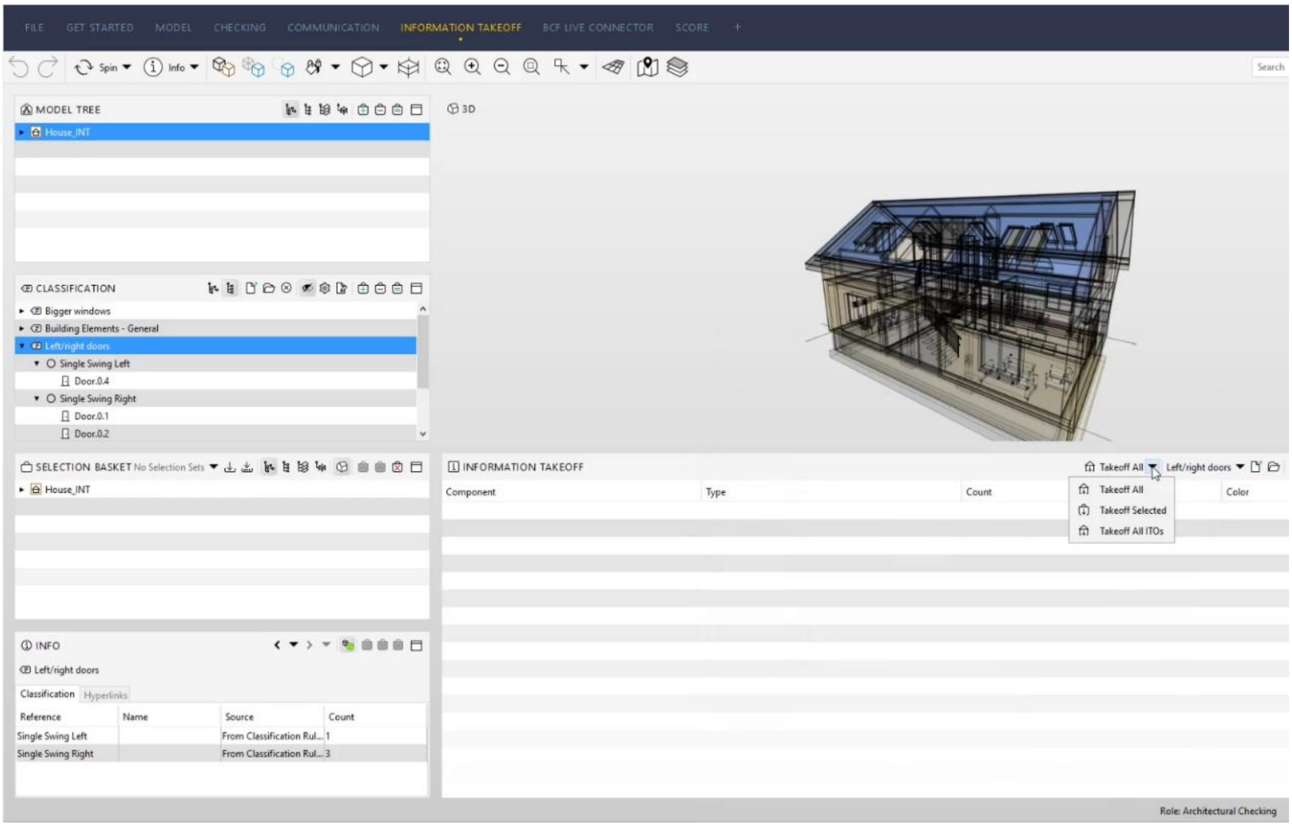

Fig. 2.5.3 A screenshot from an exercise CHAPTER 03: Take-off without counting

More details are provided in the Clash Detection Module syllabus (see Appendix).

3 Analysis of the testing phase of the BIMaHEAD e-course Modules

3.1 ENSA Nantes, France

The main expected results, the ones we needed most to elaborate our reflection and further develop the courses, were the results of "time spent doing the exercise" and "missing preconditions for doing the exercise". These two parameters were the most important as they really define the difficulty and success or failure of a module. In general, our predictions were lower than the results of the “time spent” surveys, and students generally missed more prerequisites than we expected. These major differences made us realize that there were problems in the way we were developing certain courses because we did not have the same integrated knowledge, so we forgot to explain things that seemed obvious to us but were sometimes very complicated to understand.

The trainees were mainly students from ENSA Nantes and its partner schools. A narrow majority of them did not have much experience with the learning process and materials, although they had all taken courses in computer science applied to architecture.

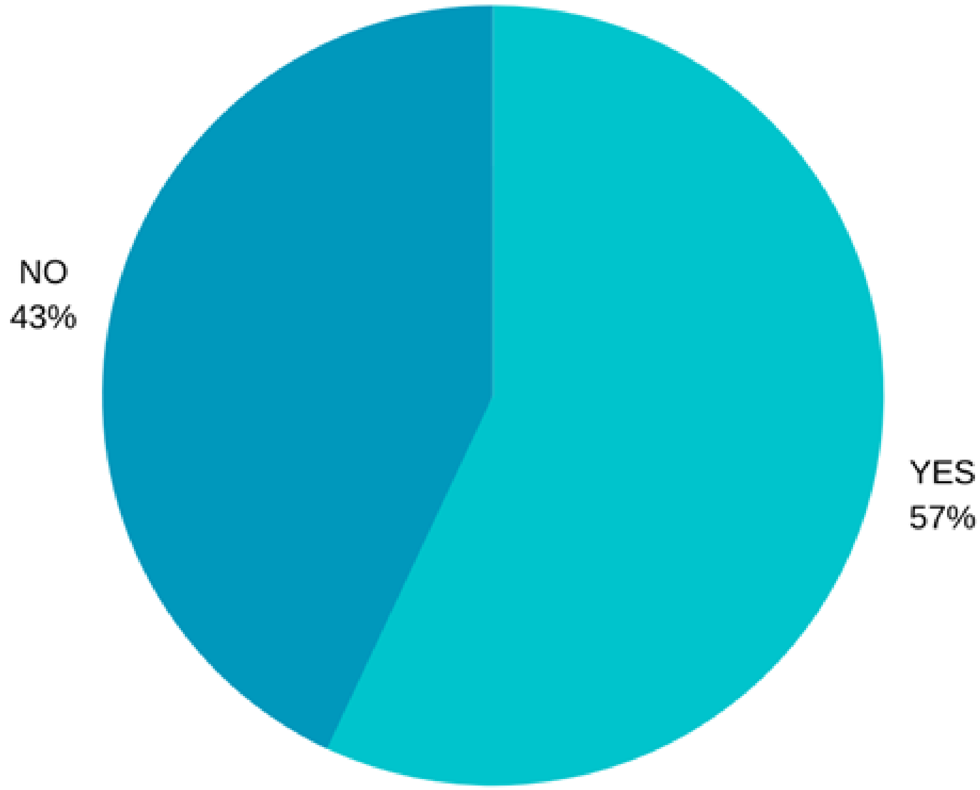

Fig. 3.1.1 A graph showing the distribution of responses to the following question: Were you missing any prerequisites?

The overall experience seems to have been a success as most participants consider that their experience of the module was positive and that their time was well spent.

If the interest of the contents, their recommend ability and their application to architecture is almost unanimous, the contents were not all as accessible, functional, and easy to handle for beginners, often depending on the performance of the hardware or software, as in the case of surface calculations with MonteCarlo, which the students found relevant without being sure of their ability to integrate it into their work habits.

Despite the reliance on software interfaces that can sometimes be difficult to access, participants generally felt that the learning platform and the innovative way in which information was delivered contributed positively to the success of the course and the learning of its content.

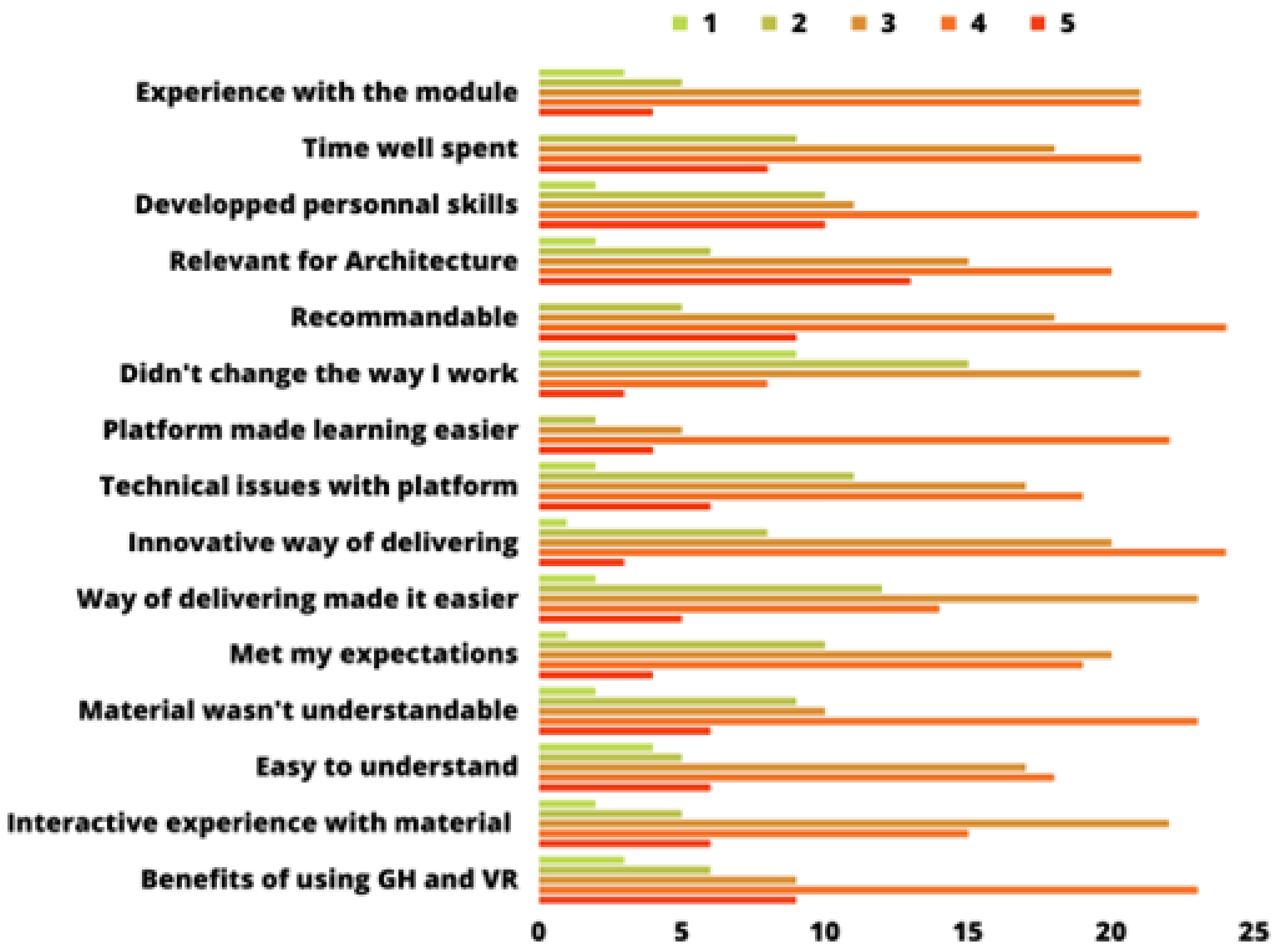

Fig. 3.1.2 A graph showing the distribution of responses to the survey on a scale of 1 to 5.

Something quite important we can tell after analysing surveys from students is the difference between our expectations and the reality on the time to complete exercises. First of all, if we focus on one specific exercise, we can note that prerequisites seem to be globally acquired by students, however, we thought that the average completing time for each exercise would be around 30min, which is not the case at all considering the vast majority of trainees took one hour or more to achieve the course. This makes the assessment complicated as one should not consider oneself as a reference and think of the potential time it would take a less experienced person, although not lacking in prior knowledge to carry out the exercise.

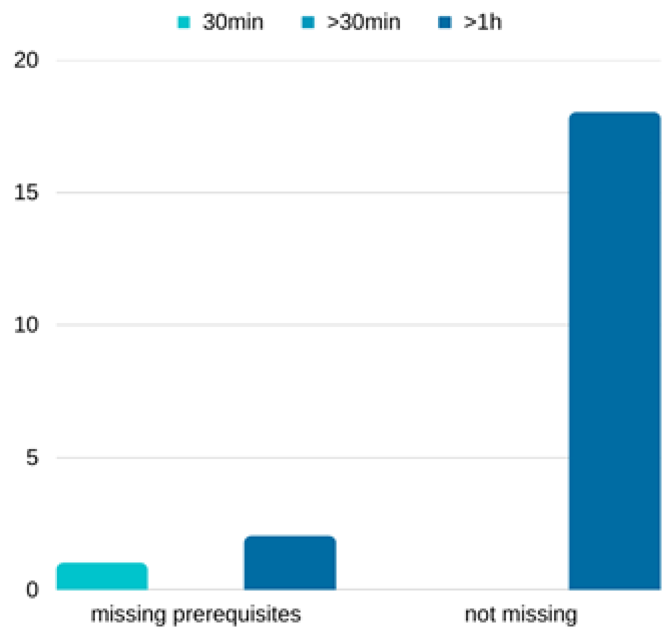

Fig. 3.1.3 A graph showing the time spent on a same exercise depending on prerequisites.

Participants were asked to complete a survey at the end of each course to highlight differences between courses and the way they were delivered, but more general questions that were answered repeatedly by the same users were only considered once.

Notable point to consider for future development or further research on specific topics on how to collect responses: There is certainly a group effect, since one can observe globally similar responses on the same exercise in the same group, when they can vary greatly from one group to another. This effect is quite positive, as students help each other and move forward together.

3.2 HCU Hamburg, Germany

The expected pedagogical outcomes planned from the learning modules

In the five exercises of the BIMaHEAD Construction module, the participants assemble virtual construction components using 3-D models. By mapping the real construction process in work steps and simultaneously assembling the corresponding virtual 3-D components, they learn how the real constructions are built and mapped as 3-D models. This interaction is essential for a constructive understanding and the basis for creating consistent BIM models. At the end of the exercises, the participants have learned how the constructive components are assembled in reality and how these components are represented as BIM models.

The learning experience of the trainees

With the development of a computer game, we ventured into unknown territory! In the first round of testing with participants from outside the project, we tested the five lessons. All participants were enthusiastic about the medium, judging it to be very low-threshold, fun and highly informative.

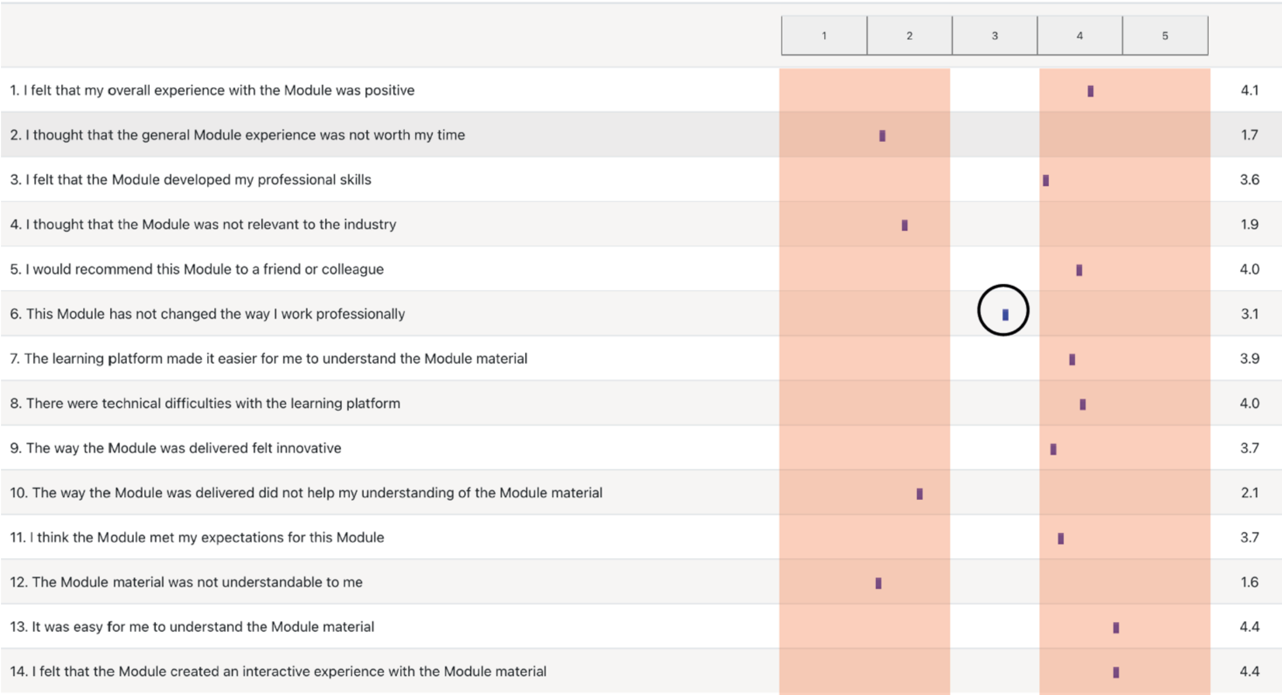

Fig. 3.2.1 Questionnaire: 1=disagree fully to 5=agree fully

However, the first virtual test rooms still had several programming errors, which the participants pointed out to us. Components disappeared during the game, lighting conditions had to be optimised, to name just a few examples. We collected all the criticisms, checked them, and analysed with what "repair effort" they could be fixed.

	Feedback	**Frequency**	**Realizability**
Technology	Program gets stuck	2	Middle
	Control not easy with trackpad	1	Difficult
	Building materials disappear or are difficult to grab	14	Middle
	Saving option for technical Problems	3	Middle
	Show progress to completion of the component	1	Middle
	Respawn for falsely placed materials	5	Difficult
	WP 2 not successfully finishable	10	Middle
	Unlabeled white signs in the exit (module 2-5 without explanation)	4	Easy
	Building material must be held constantly (hold and release by key combination)	1	Difficult
	Independent rotation function of the structure	2	Difficult

Fig. 3.2.2 Collected improvements, technology: blue=basic improvement, red=urgent improvement

Graphics & Sound	Building materials are difficult to recognize (abstraction)	1	Middle
	Building materials are difficult to recognize (in front of background) Film in front of hard insulation Too dark	5	Middle
	The font is difficult to see	4	Middle
	Sound or similar for correct and incorrect actions	3	Difficult
	Arrangement of materials: building materials are lost when the field of vision is turned, building materials and structure should be visible at the same time, dizziness due to constant turning	9	Middle
	Larger space to view building better	1	Middle
	Material labeling in WP5 incorrect	1	Middle
	Display material section as vector hatching	1	Difficult
	Effect on successful completion of the structure	1	Difficult

Fig. 3.2.3 Collected improvements, graphics, and sounds

Didactics	Better program introduction Where do materials need to be located? Generally unclear introduction Step by step explanation Explain expectations: What is expected of the student? Animation for material placement	5	Difficult
	The ratio between learned content and effort to learn the program is not yet balanced	1	
	Add support window	1	Difficult
	Higher level of detail of the modules	1	Difficult
	The information window is related to the work step: Why is this work step now applied before the other?	4	Middle
	Incorporate variations in the execution process	3	Difficult
	CAD drawing retrievable via key combination	1	Difficult
	Sequence of floor construction varies	2	Difficult
	WP5 Door lintel missing	2	Difficult
	WP3 Foil on insulation missing	2	Difficult
	WP3 Facade not matching detail	1	Difficult
	WP4 Window lintel as an extra work step	1	Difficult

Fig. 3.2.4 Collected improvements, didactic issues

This prompted us to redesign entirely rooms and scenarios and to relaunch the project until the National Workshop.

A second test-run worked smoothly, and the participants encouraged us to implement these modules in regular university teaching. The learning objectives of learning the construction process and transferring it to a 3D model were achieved and confirmed by the participants.

The ergonomic, usage experience, design of the content

The exercises can be experienced on a standard computer, using a game console, or VR headsets. The operation was mostly found to be simple and clear (especially by participants experienced in computer games). The exercises were a lot of fun for all participants. The games resemble a quiz in which one can make mistakes. Completing the exercises is associated with success. All participants would like to see this new form of teaching improved and expanded further.

Teaching approach and methodology analyses

The participants work out their constructive knowledge themselves in a quiz-like 3D game. If they make mistakes, they have to correct them until the 3D model is assembled correctly, i.e., in the correct constructive order. Through this self-work, learning by making mistakes and the sense of achievement when they have finished building a component, we consider this learning process to be much more efficient than the usual teaching formats such as lectures, seminars, and group exercises.

3.3 HH Halmstad, Sweden

Two rounds of testing have been conducted during the development of the module. In the first phase software (VICO) already used in existing teaching was used. In order to give a broader description of the process of using software tools a second, and for the students at HH new, software was introduced as well (Bidcon). In this first testing phase, the students were provided with a demonstration of the software and then they were encouraged to test the two available software packages and form an understanding of the capabilities of the software packages. They were also given the opportunity to do manual calculations in order to compare the manual process with the software-based process. This first phase enabled development of an understanding of how students perceived the use of the software, and how the absorbed the provided knowledge.

Overall, the students had similar opinions about the first phase. They thought that they were given a good or very good basis regarding the software and the methods. They could see that digital tools to a high extent simplify the work with calculations and how BIM-models enable an effective work with calculations and that the digital world contributes with different pros and cons. Due to mistakes that the students made they also saw that they need construction skills as well as that there is a need to know what they are doing. The students thought that the sessions and exercises increased their knowledge about digital calculation.

Reflections on the material was that it provided a basis but that more knowledge is needed to be proficient in working with digital calculation and there is a need of a greater extent of work to be good. More specific comments were that you can see that the tools are very useful bit that you need specific construction knowledge to calculate which was validated by other interviewees. A reflection was also that it would be useful to use the tools more frequently in the education to make them a part of the everyday education. They could also work more practically with the transfer of information. A point was also that a review is needed to show how work is done when not all is available digitally, like for example with pdf-drawings. It can also be good as a prolongation to work with the software's to a greater extent, since the students watch a demonstration video and then have to look at specific examples. Hence, the first testing phase validated the key issues with the whole BIM-ahead project, providing a basis that universities can build on. In addition, the students also stress a need for other modules as well, which are covered by the other partners as well.

The experiences from the first phase were used as input for the development of the finalized module. A main difference with the finalized module is that the learners do not work in the software as this needs licensing and control and is replaced by demos. Furthermore, the mistakes made by the students was useful input for the examples provided in the finalized module.

After the second phase and the alterations made, the students thought that the module was very good and useful and provided a basis for continued education/learning by using specific tools. The videos with quizzes in between was a good setup and also the educational points that came up during the course. A short text about what the videos treated could however be added. Otherwise, it was easy to understand, nice and professional with a good design and as stated providing a good basis for continued learning.

3.4 IECE Skopje, North Macedonia

The expected pedagogical outcomes planned from the learning modules

Regarding the relevance of the Module to Industry, 77% of students strongly agreed that the module is relevant and 23% agreed to some extent. When asked about the way the module was delivered, and whether the material was understandable, 77% or 92% strongly agrees that it is understandable.

Regarding whether the Module increased their skills in BIM energy calculation and evaluation, 38% answered that they completely agreed and 53% agreed to some extent.

The learning experience of the trainees

When asked about the overall positive experience and whether the module met the students' expectations, 77% had a positive overall experience and 85% answered that the module met their expectations.

The ergonomic, usage experience, design of the content

About the level of understanding and using the digital strategies of BIM Energy calculation and evaluation, 77% answered that the module increased their level of understanding and 54% of using the digital strategies. 63 % of the trainees will recommend this module to a friend or a colleague.

Teaching approach and methodology analyses

Most of the trainees said that the module was innovative and felt that the module material was interactive. Also, they think that the learning platform made it easier for them to understand the Module material.

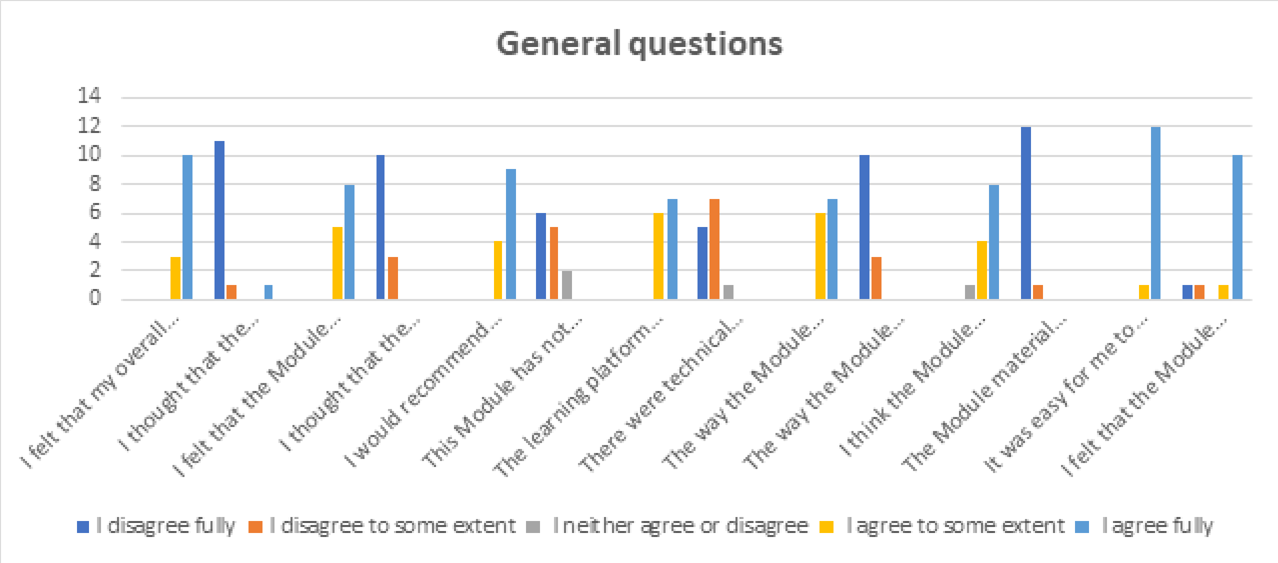

Fig. 3.4.1

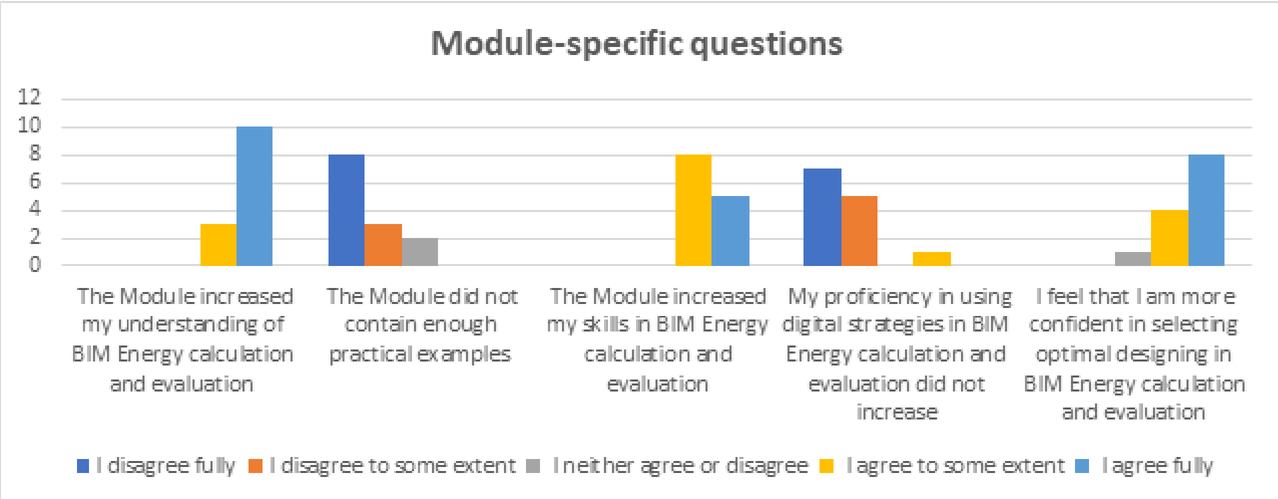

Fig. 3.4.2

3.5 TUL Lodz, Poland

The testing phase was one of the major milestones of the whole Project. The BIMaHEAD team at TUL, Poland, called it beta-testing of the product. Testing the product by users who had never seen it before was crucial for collecting genuine and accurate observations and reliable feedback from participants.

According to the Project description, it was expected to test the product on 20 users. In fact, the Clash Detection Module was tested by 25 students that took the Module at the same time. None of them had a prior knowledge in clash detection domain or software skills. All students were given the same time for experiment. Additionally, at the end of the testing they were asked to fill an anonymous questionnaire that allowed for grading the experience and writing opinions.

From the product design and e-learning experience development perspectives, the questionnaire had a prominent value. That is why it had been designed and discussed in detail with other Partners before the testing phase and adapted to each module specifics. Here is the final shape of the questionnaire used for the Clash Detection Module:

Scale:

I agree fully / I agree to some extent / I neither agree or disagree / I disagree to some extent / I disagree fully

Questionnaire instruction:

You are going to be given a few statements about the Module you have completed. We want to know how much you agree or disagree with these statements.

General questions:

1. I felt that my overall experience with the Module was positive
2. I thought that the general Module experience was not worth my time
3. I felt that the Module developed my professional skills
4. I thought that the Module was not relevant to the industry
5. I would recommend this Module to a friend or colleague
6. This Module has not changed the way I work professionally
7. The learning platform made it easier for me to understand the Module material
8. There were technical difficulties with the learning platform
9. The way the Module was delivered felt innovative
10. The way the Module was delivered did not help my understanding of the Module material
11. I think the Module met my expectations for this Module
12. The Module material was not understandable to me
13. It was easy for me to understand the Module material
14. I felt that the Module created an interactive experience with the Module material

Module-specific questions:

15. The Module increased my understanding of clash detection
16. The Module did not contain enough practical examples
17. The Module increased my skills in clash detection in design process
18. My proficiency in using digital strategies in clash detection did not increase
19. I feel that I am more confident in selecting appropriate tools for digital clash detection

Open ended questions:

20. Describe what could be improved with the module: [non limited text]
21. Describe what you think was the best with the module: [non limited text]

Here are the outcomes of the user experience evaluation of the Clash Detection Module. The numbers visible in the bars of the graphs indicate the number of students who selected a given answer.

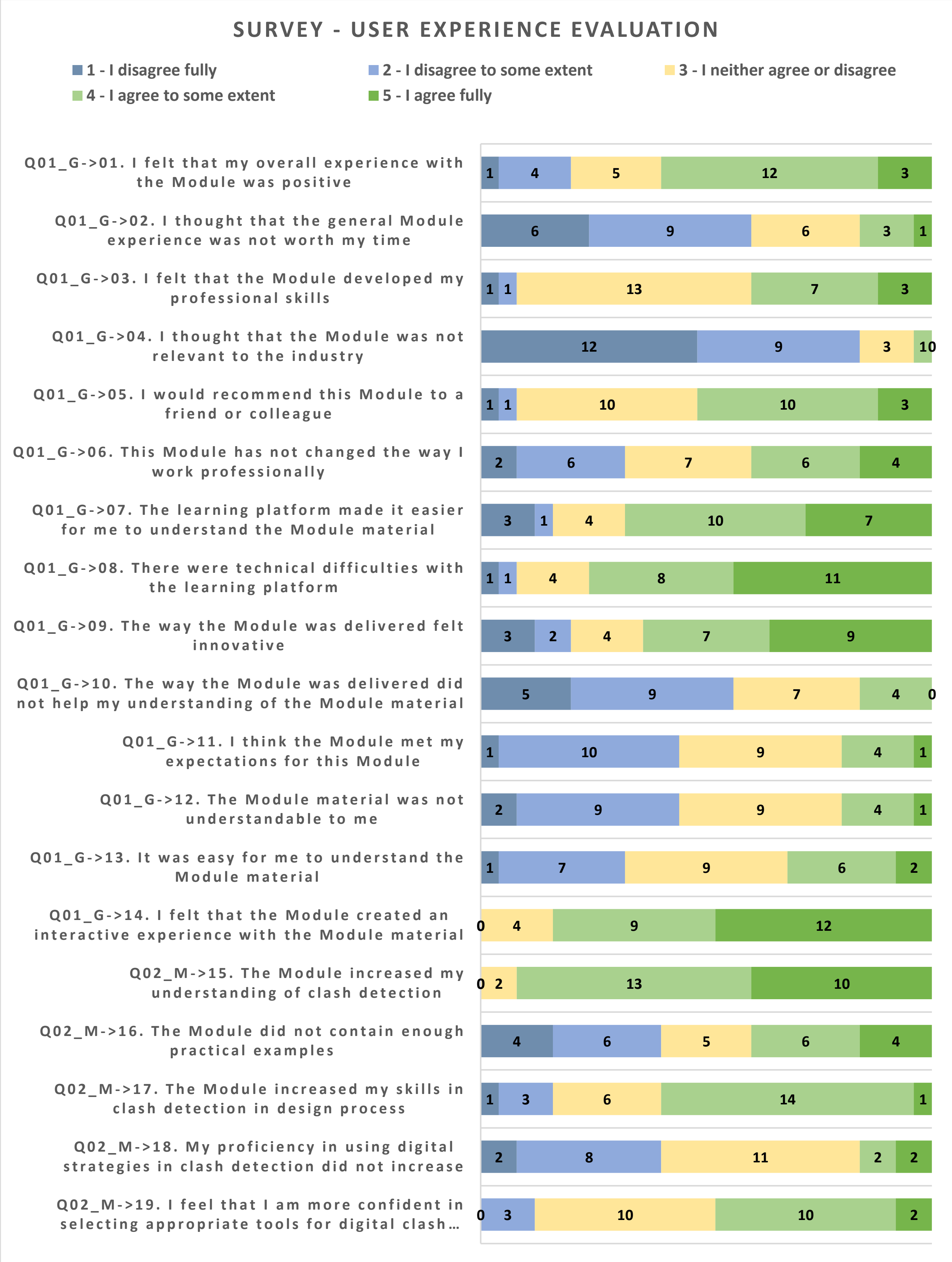

Fig. 3.5.1 Overall survey results of the User Experience Evaluation

General questions:

60% of students considered their experience with the module positive, of which 12% fully. Only 1 person (4%) disagreed completely, 4 (16%) partially.

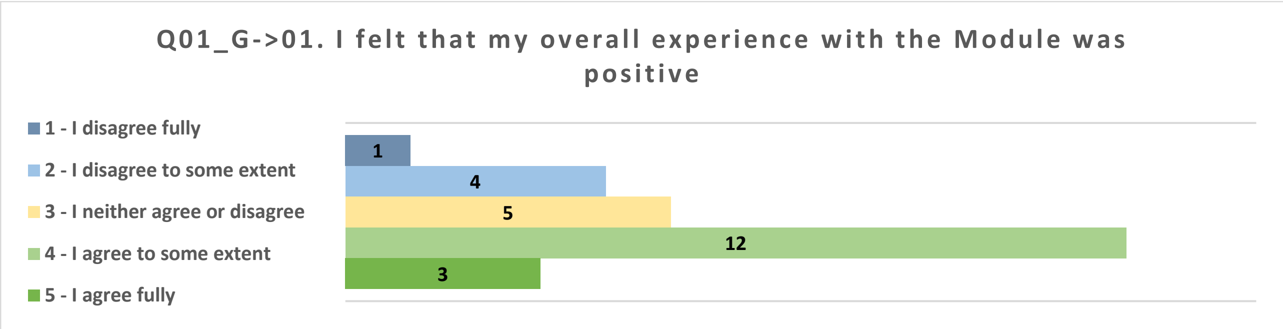

Fig. 3.5.2 A graph showing the distribution of responses to a question Q01_G->01: "I felt that my overall experience with the Module was positive".

60% of students, 24% of whom fully, disagreed with the statement that working at Module was a waste of their time. Only 3 respondents agreed partially and 1 fully (16% in total).

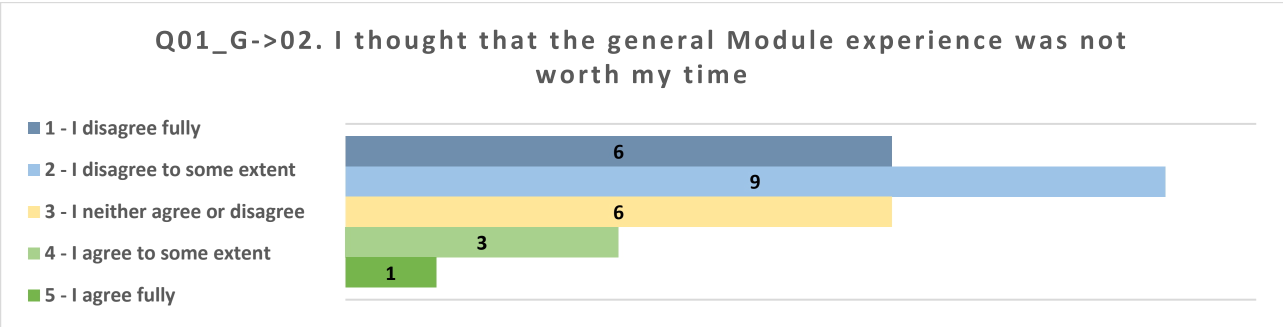

Fig. 3.5.3 A graph showing the distribution of responses to a question Q01_G->02: "I thought that the general Module experience was not worth my time".

40% of students (of which 12% fully) felt that the module developed their professional skills. The majority (52%) had no opinion. 1 student disagree completely, 1 partially.

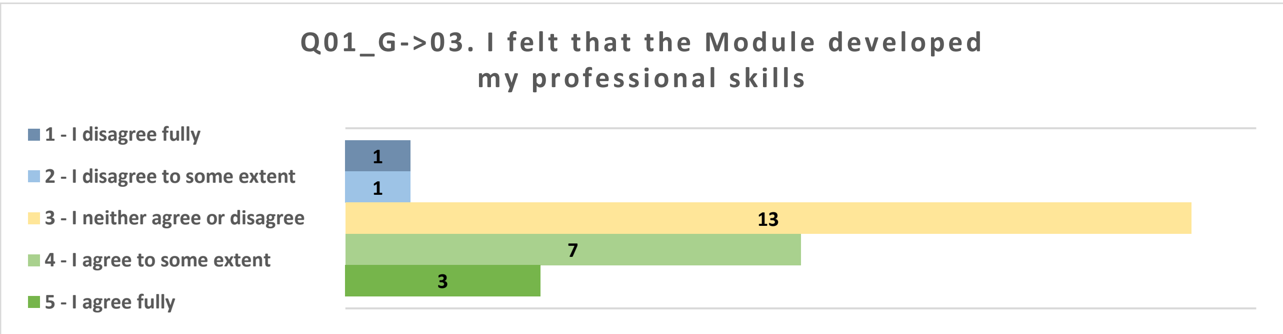

Fig. 3.5.4 A graph showing the distribution of responses to a question Q01_G->03: "I felt that the Module developed my professional skills".

The vast majority (84%), of which 48% completely, disagreed with the statement that the Module was not relevant to the industry. Only one person partially agreed with this.

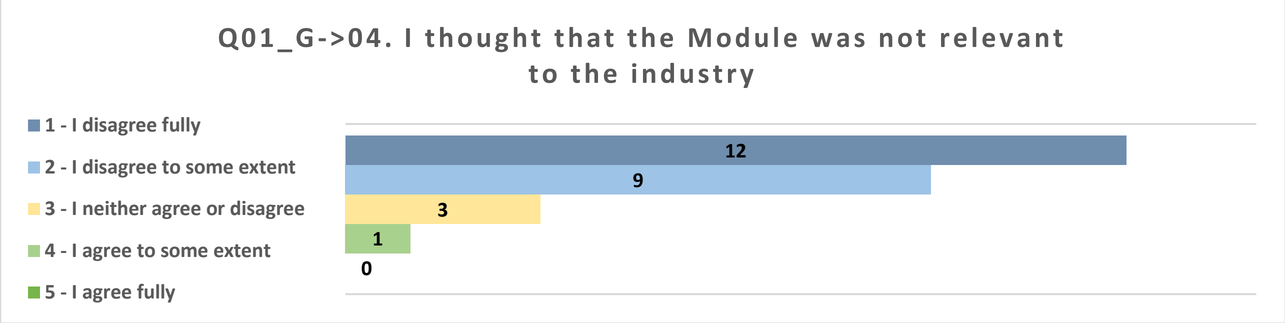

Fig. 3.5.5 A graph showing the distribution of responses to a question Q01_G->04: “I thought that the Module was not relevant to the industry”.

52% of the respondents would recommend the module to a friend or colleague, most of them (40%) definitely. 40% had no opinion. Only 2 people (1 definitely) would not recommend the Module.

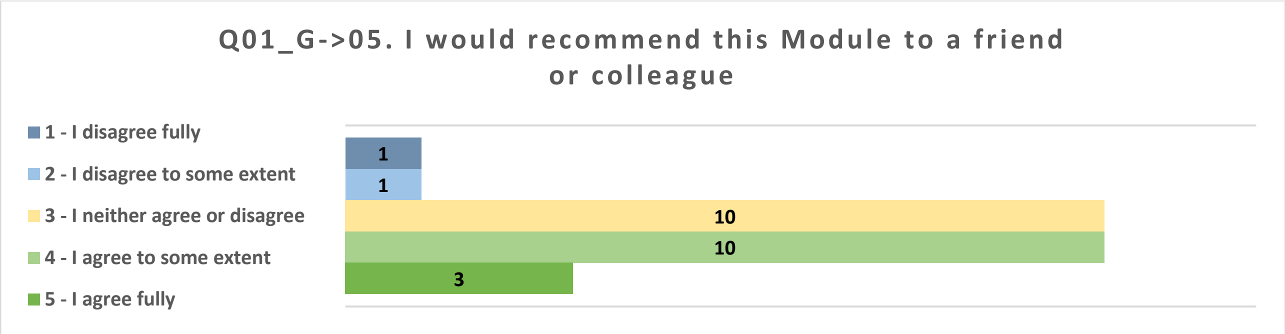

Fig. 3.5.6 A graph showing the distribution of responses to a question Q01_G->05: “I would recommend this Module to a friend or colleague”.

40% of students (16% fully) agreed with the opinion that the Module did not change the way they work. 32% (8% totally) disagreed, 28% were unsure.

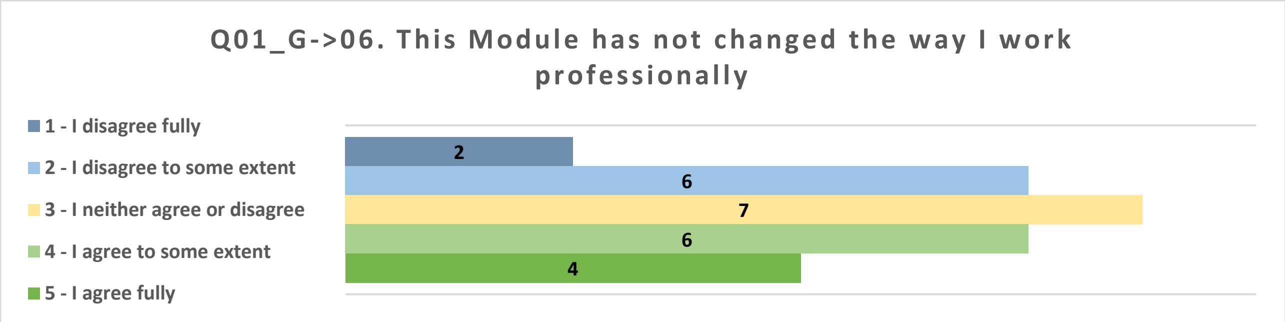

Fig. 3.5.7 A graph showing the distribution of responses to a question Q01_G->06: “This Module has not changed the way I work professionally”.

Most of the respondents (68%), of which 28% fully, agreed with the opinion that the learning platform made it easier for them to understand the Module material. 12% disagreed fully, 4% - partially.

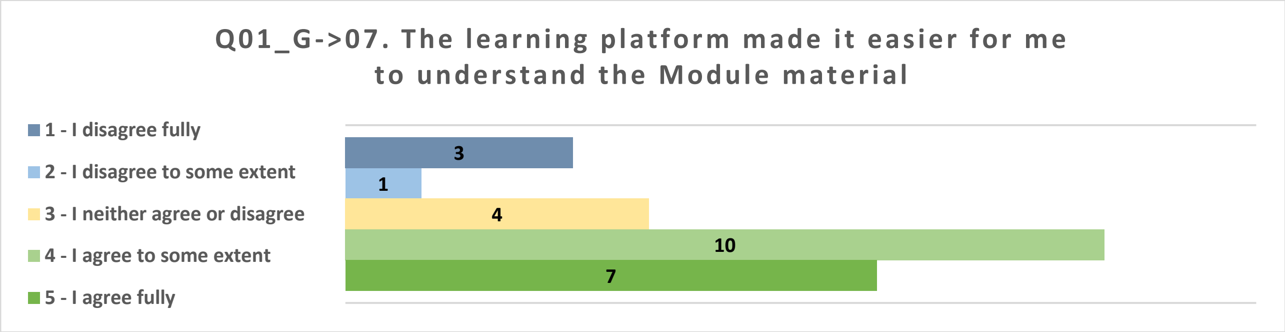

Fig. 3.5.8 A graph showing the distribution of responses to a question Q01_G->07: "The learning platform made it easier for me to understand the Module material".

76% of students indicated technical problems with the learning platform. Only 2 people, 1 of whom completely, disagreed with this opinion.

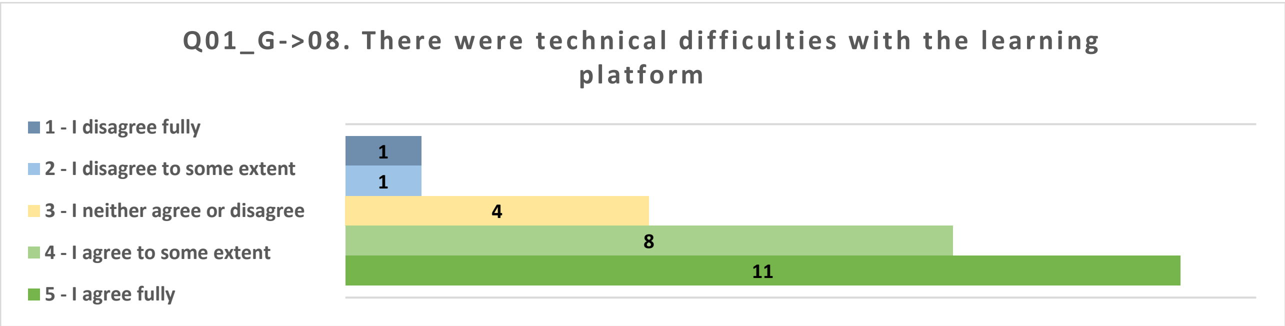

Fig. 3.5.9 A graph showing the distribution of responses to a question Q01_G->08: "There were technical difficulties with the learning platform".

64% of respondents (36% fully) considered the way of delivering the Module innovative. 20% (12% fully) disagreed.

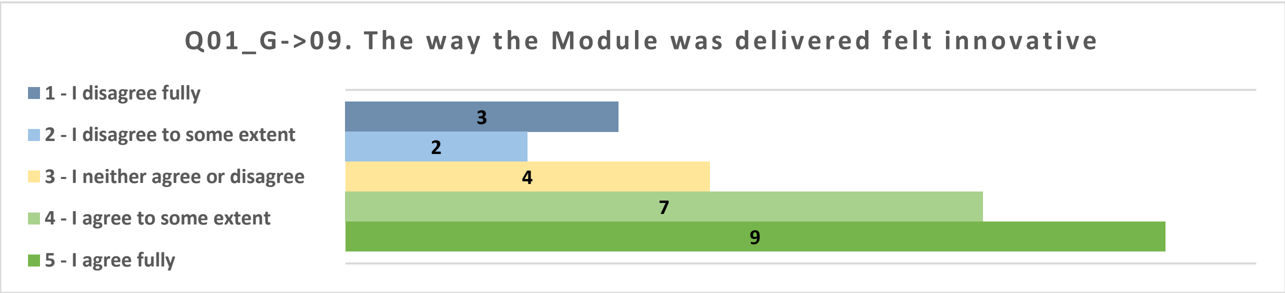

Fig. 3.5.10 A graph showing the distribution of responses to a question Q01_G->09: "The way the Module was delivered felt innovative".

56% of students disagreed with the opinion that the way of Module delivering did not help them understand the Module material. No one fully agreed with this, 16% - partially.

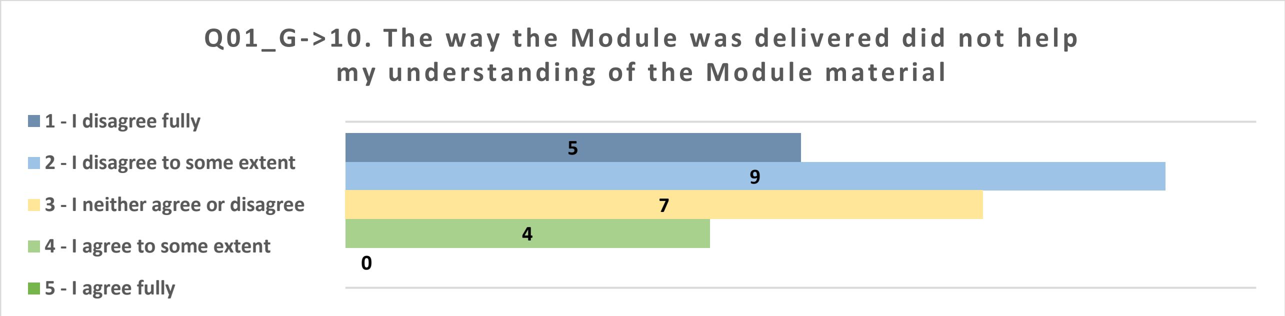

Fig. 3.5.11 A graph showing the distribution of responses to a question Q01_G->10: “The way the Module was delivered did not help my understanding of the Module material”.

The module met the expectations of only 20% of students (including 1 person fully - 4%). Completely did not meet the expectations of 1 respondent, 40% - partially.

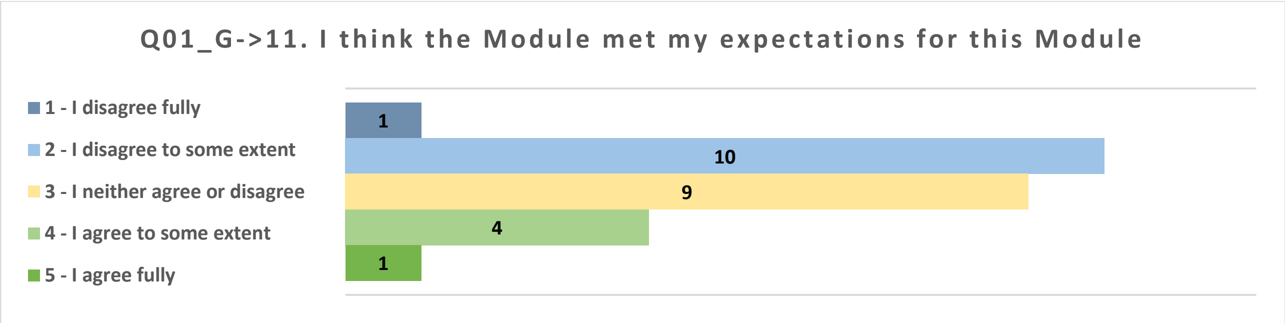

Fig. 3.5.12 A graph showing the distribution of responses to a question Q01_G->11: “I think the Module met my expectations for this Module”.

For only 20% of people the material of the module was not understandable (including for 2 people fully - 8%). 44% disagreed with this statement, of which 2 people completely.

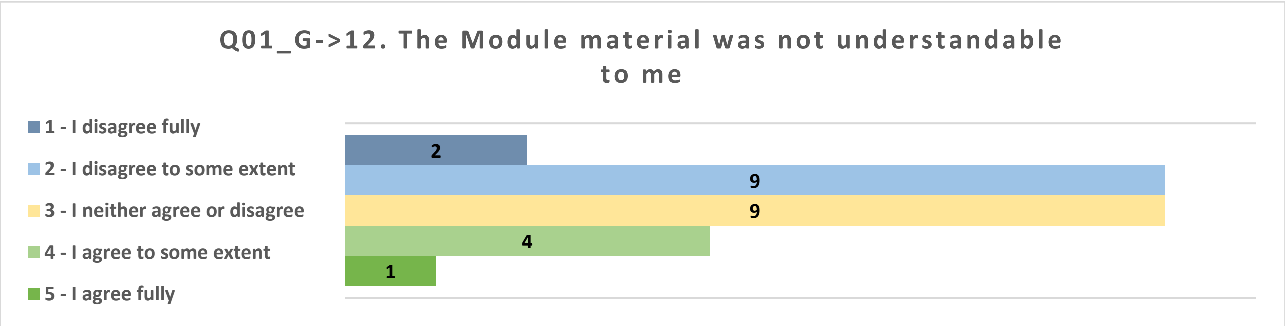

Fig. 3.5.13 A graph showing the distribution of responses to a question Q01_G->12: “The Module material was not understandable to me”.

It was easy to understand the Module material for 32% of students (including 8% fully - 2 persons). For 28% of respondents, it was not easy to some extent and only for 1 respondent completely.

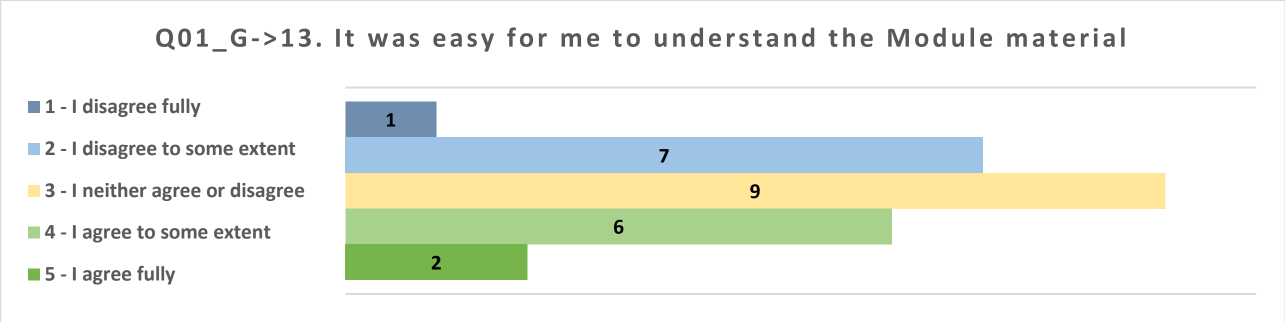

Fig. 3.5.14 A graph showing the distribution of responses to a question Q01_G->13: “It was easy for me to understand the Module material”.

The overwhelming majority of students (84%), of which 48% fully, confirmed that the module created an interactive experience with the material of the module. No one, even partially, denied the opinion above.

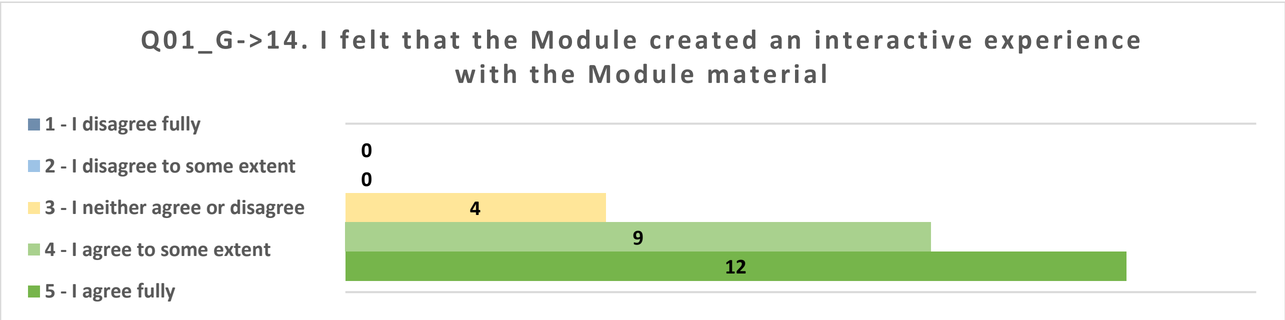

Fig. 3.5.15 A graph showing the distribution of responses to a question Q01_G->14: “I felt that the Module created an interactive experience with the Module material”.

Module-specific questions

Almost all students (92%), of which 40% strongly, confirmed that the Module increased their understanding of clash detection. Not a single person contradicted the above statement. Only 2 respondents had no opinion.

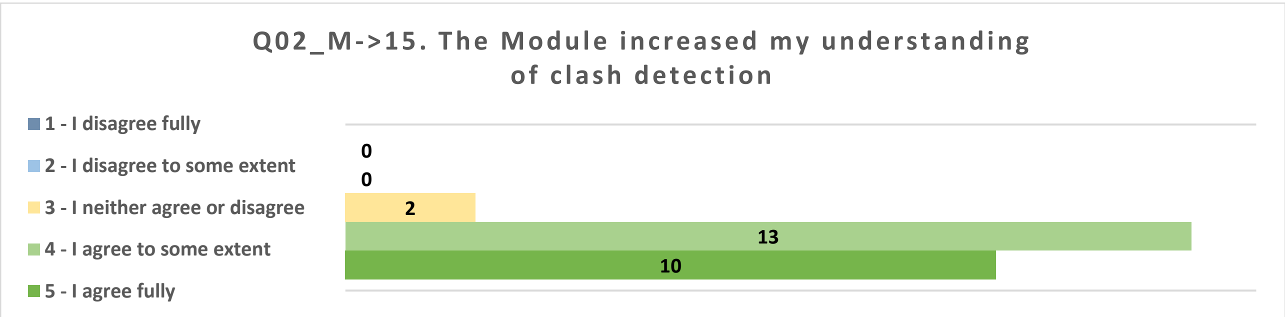

Fig. 3.5.16 A graph showing the distribution of responses to a question Q02_M->15: “The Module increased my understanding of clash detection”.

The answers to the following question were evenly distributed: according to the opinion of 40% of respondents, of which 16% were certain, the Module did not contain enough practical examples. Also 40% (including 16% fully) disagreed with this statement. 20% of students were undecided.

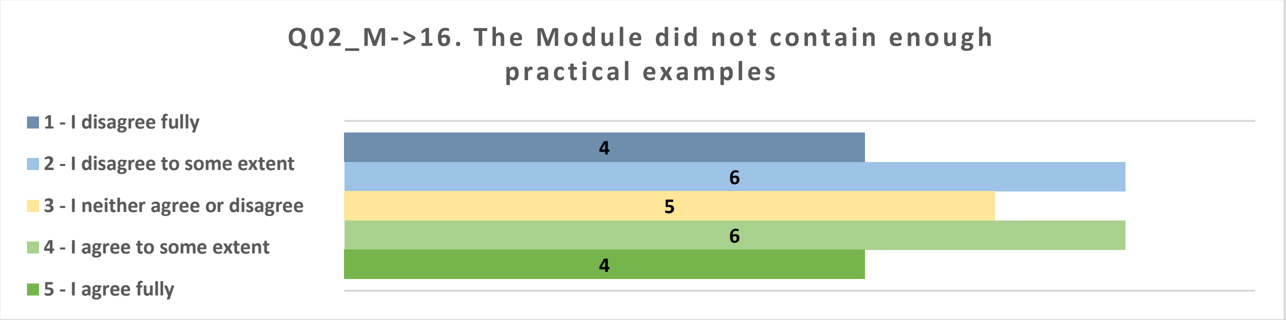

Fig. 3.5.17 A graph showing the distribution of responses to a question Q02_M->16: "The Module did not contain enough practical examples".

56% of people responded that the Module to some extent had improved their skills in clash detection in the design process. 1 student (4%) fully agreed with this. 12% denied it partially, and only 1 person completely.

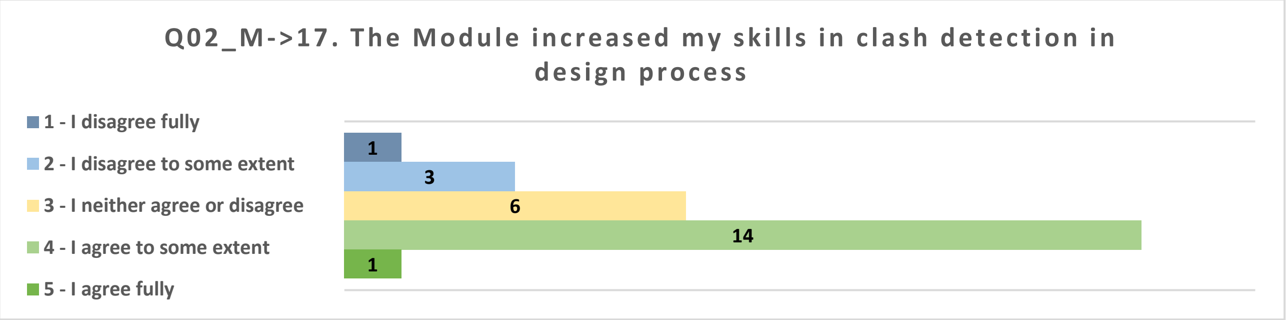

Fig. 3.5.18 A graph showing the distribution of responses to a question Q02_M->17: "The Module increased my skills in clash detection in design process".

Only 4 students (16%), half of them definitely stated that the Module did not increase their proficiency in using digital strategies in clash detection. 44% were undecided. 40% (including 8% fully) disagreed with the opinion above.

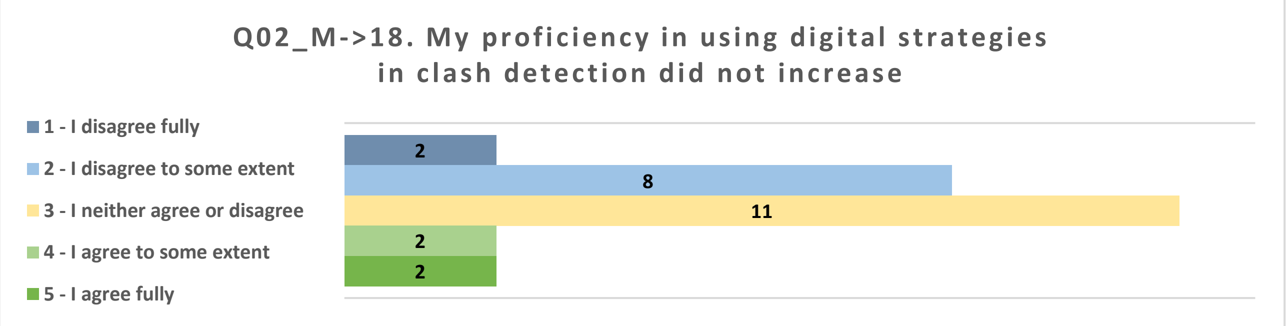

Fig. 3.5.19 A graph showing the distribution of responses to a question Q02_M->18: "My proficiency in using digital strategies in clash detection did not increase".

48% of respondents felt that they were more confident in selecting appropriate tools for clash detection. No one denied that statement, 12% disagreed to some extent. 40% of the students had no opinion.

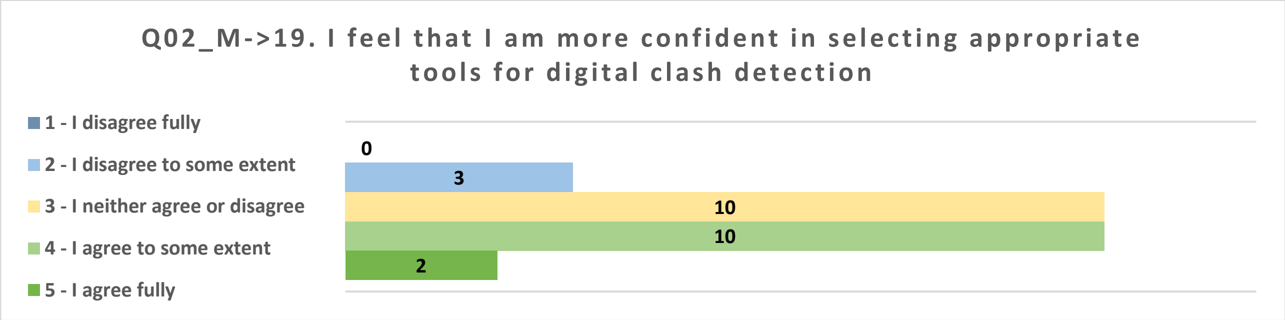

Fig. 3.5.20 A graph showing the distribution of responses to a question Q02_M->19: “I feel that I am more confident in selecting appropriate tools for digital clash detection”.

Open ended questions

Participants delivered significant feedback that allowed to reflect upon user experience and to develop the product. Here are some examples of Q&A:

Question Q03_O->20: "Describe what could be improved with the Module"

In their answers to the above open question, students paid special attention to the problems with the surprising mechanics of movement in the spatial.io virtual space, handling of the Solibri application, which they were unfamiliar with, as well as the way some multimedia materials worked. They suggested the need to supplement the text commands in the videos with voice comments, to clarify the explanations. They would expect a clear task list. In some materials, students lacked the ability to go back to parts they did not understand.

Question Q03_O->20: "Describe what you think was the best in the Module"

Answers to the above question contained praise for the idea of using the spatial.io virtual space, presenting 3D examples of collisions and tasks to be performed. The platform, although somehow distracting, made learning more attractive, introduced an element of fun and encouraged further exploration of the Module. They compared learning in the Module to a video game. Students pointed out that thanks to the Module they discovered new possibilities of the well-known BIM program (ArchiCAD). They appreciated the theoretical part, which contained explanations of concepts. They liked interactive, replayable videos, enriched with comments and questions because it kept learners focused. Students also found it sensible to start learning in the Module with a knowledge test. It is desirable for students to receive a certificate for completing the course.

4 Reports from the National Workshops

4.1 ENSA Nantes, France

Date of the National Workshop, place, number of participants

21st to 25th of February 2022. ENSA Nantes 15 people. Nirma University 15 people.

Workshops description

During the week of February 21 to 27, 2023, workshops are organized in partnership with Nirma University, a private Indian school. During this week, the topic is about collecting information during the educational experience carried out on the Spatial.io platform. The experiments under study are conducted at ENSA Nantes, with French students and teachers. The interaction between the two partner groups will question us about the possible cultural differences noted in the handling of the metaverse studied platform. Among the planned experiments, a 1-hour experiment at the Coraulis is planned in order to confront this immersive device with the issues raised by the workshop (quality of immersion in the platform and use for design purposes). On February 17, a meeting is organized with the Indian participants of the Workshop, the objective of the meeting is to prepare the students on the theme of the experience to come. Like the Matryoshka, the Spatial.io experience tests the stratifications in the design of the architectural project. The Russian doll effect is a metaverse metaphor, forming layers of project: it is an architecture project within a metaverse project. The challenge for the students is to create the context that will host the designed architectural project, and to reproduce the stages of the design process. The students will be able to experiment with new ways of project's presenting – outside the framework of the studio – by choosing a project that is already modelled or creating one for the occasion (by favouring a small-scale project to limit the difficulties in importing, the urban projects can be chosen, taking care however to choose a relevant scale of presentation).

Workshop scenario

- Day 1: formation of groups and presentation of the week's proceedings and working conditions. introduction to the challenges of the courses given.
- Day 2: Students start with the modelling exercises and experiments with software (Blender, Rhino, Sketchup...). They began to experiment with VR headsets through Spatial.io. They are asked to prepare an environment of their choices that they will have to present in the VR space.
- Day 3: Discussions on how to organize and set up the collective room for both Indian and French students. Meeting with participants from India. Continuation of experiments and development of common or personal projects.
- Day 4: Pursuit of experiments and tests. experiment is conducted at Coraulis. Several video environments are projected, and students are invited to answer questions about their feelings about a street they walk down as a "pedestrian" in the virtual space. Coraulis is a 360° immersive setup

and was used to confront students with the challenges of visualization in VR (that they had to try before in the field of BIMaHEAD's course) while putting into perspective the use of a space allowing the diffusion to several people.

- Final day: Students finalize their individual spaces. The models are completed, and they all present them in the common Matryoshka space in Spatial.io to complete the "form finding" course process = from the creation of a shape to its experience in real scale with multiple people in a same virtual space.

Feedback from the participants

The workshop was planned on developing individual projects thanks to technical courses and then experimenting results in virtual reality, but the main objective was to analyse how they were acting as a studying group when confronted to experimenting in virtual space and developing projects side by side, helping each other, discussing complex topics together and trying to create a convincing collective room that they could all visit. Depending on the project intentions (manipulation in brick time, contemplative environment, abstract landscape…), the degree of physical involvement during the design process is changed. The interaction with the virtual environment during the design process depends on the intended use of this universe in the headset (walking around, looking, manipulating…).

The navigation between all the rooms is integrated by the students, they navigate willingly in the spaces of the others. After a few days of mastering the VR tools, the students become experts and teach in their turn. The French students favour sensory effects (loss, vertigo, reversal, etc.), while the Indian students favour the possibilities of structures or large built spaces. Learning by observing other peers is also a quality of this experience: going to see other students, comparing possibilities, intentions, and techniques of others (and comparing possible cultural differences).

Fig. 4.1.1 A set of photos of the National Workshop taking place in Nantes: people working between the physical and the virtual space

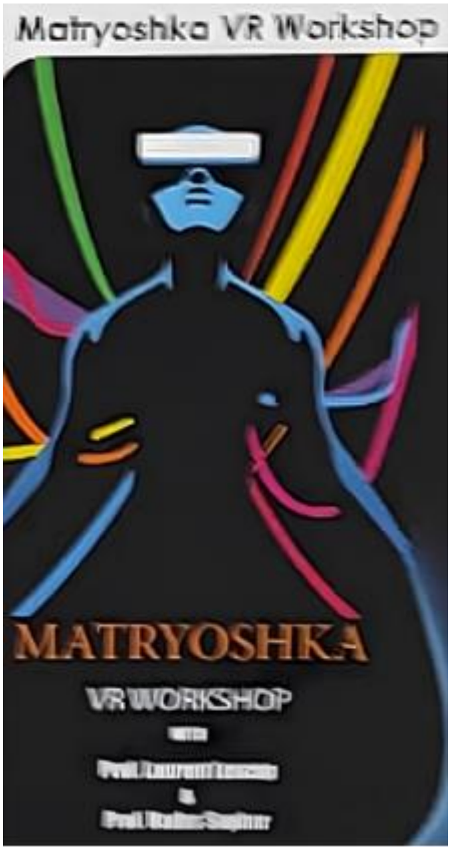

Fig. 4.1.2 A poster of the workshop conducted in partnership with India

4.2 HCU Hamburg, Germany

The National Workshop took place on 9 May at HafenCity University. 36 participants took part in the workshop.

The workshop was intended to provide information about the BIMaHEAD project, an assessment of the participants and to test the operation of the Moodle pages under the observation of the BIMaHEAD project participants in order to subject the project to a reality check. Furthermore, we wanted to get an assessment of the didactic effectiveness through observations and from the participants.

During the workshop, the BIMaHEAD project and its goals were presented. Afterwards, the Moodle page was presented via beamer and first instructions on how to use it were given. This enabled some questions to be answered directly. Afterwards, the participants completed the exercises in Moodle and the virtual rooms and gave direct feedback to the organisers. The BIMaHEAD project participants were thus able to see directly how the workshop participants were able to complete the exercises, where there were difficulties and under what conditions the system reaches its limits. This was a kind of crash test. The participants were divided into successive groups so that all participants could experience the virtual spaces via notebook and VR headset (4 headsets) and comment on the different forms of access.

Statement (scale 1–5)	Mean
1. I felt that my overall experience with the Module was positive	4.3
2. I thought that the general Module experience was not worth my time	1.5
3. I felt that the Module developed my professional skills	3.5
4. I thought that the Module was not relevant to the industry	1.8
5. I would recommend this Module to a friend or colleague	4.0
6. This Module has not changed the way I work professionally	3.2
7. The learning platform made it easier for me to understand the Module material	4.3
8. There were technical difficulties with the learning platform	3.0
9. The way the Module was delivered felt innovative	4.2
10. The way the Module was delivered did not help my understanding of the Module material	1.8
11. I think the Module met my expectations for this Module	4.0
12. The Module material was not understandable to me	1.6
13. It was easy for me to understand the Module material	4.1
14. I felt that the Module created an interactive experience with the Module material	4.6

Fig. 4.2.1 Re-evaluation during national workshop, same questions for comparability: 1=disagree fully, 5=agree fully

The most interesting feedback or observation during the workshop was direct and is not reflected in the questionnaire. With the BIMaHEAD "game", quasi hidden exercises, we reach students who do not participate or do not appear in the usual university formats. It is possible to achieve results with exercises that do NOT rely on language skills compared to the usual formats. Thus, we have given participants with language barriers an opportunity to participate equally in the study of architecture. In addition, students who are experienced in computer games were able to assist their fellow students. Gaming is becoming a competence and young people with gaming experience were able to find social connections through the teaching of this competence. On the whole, the initiative was consistently praised, and the didactic goal achieved. Games-experienced participants sometimes criticized the graphics, games-inexperienced participants sometimes had difficulties with the operation and the processes of the lessons.

For the most part, BIMaHEAD was evaluated very positively, and the participants developed ideas for optimisation, further development, and expansion of the content.

Fig. 4.2.2 A photo from National Workshop at HCU

Fig. 4.2.3 A photo from National Workshop at HCU

4.3 HH Halmstad, Sweden

National Workshops were held at two occasions, 21st of April and the 15th of May. In addition, the project will be presented at a national meeting covering a majority of the B.Sc. programmes in Construction Engineering on the 15-16th of June 2022. During the national workshops, a wide array of participants has been included. Participants include teachers from different universities around Europe, university students and representatives from the construction industry. The national workshops have established that there is an interest of following the completion of the BIMaHEAD project. Furthermore, participants in the national workshops actively expressed an interest in using the output of the BIMaHEAD project in their own teaching and training efforts as well for use in the professional organisations that attended. The content was viewed as complementary to own educational efforts on BIM. The methodological approach of the BIMaHEAD module was viewed by the participants as helpful in increasing BIM maturity and diffusion and that the design of the module was easily accessible for both academic and non-academic learners.

However, industry feedback states there are many similarities between different digital tools and that software-specific training is best provided "on the job". The feedback suggests that a specific software, or specific skills of using a particular software may not be that important, but rather that the important issue is to understand the process of using software tools during the calculation and estimation stage of a construction project.

Judging from the response of the industry-representatives in particular, the climate module and climate assessment part was of even greater interest than the digital calculation part since this is the current most challenging issue. The companies attending from the user-side had already software in place. Reviewing the Module, concrete points were that using nos on the lectures should be avoided since it complicates updates and that a timeline showing where the user is in the module. Otherwise, much of the opinions that were raised during testing two were confirmed and the aims with the Module were validated as useful. The second also raised other interesting topics regarding digital tools and one representative raised the need to validated models, since there can be built in faults in the digital information provided.

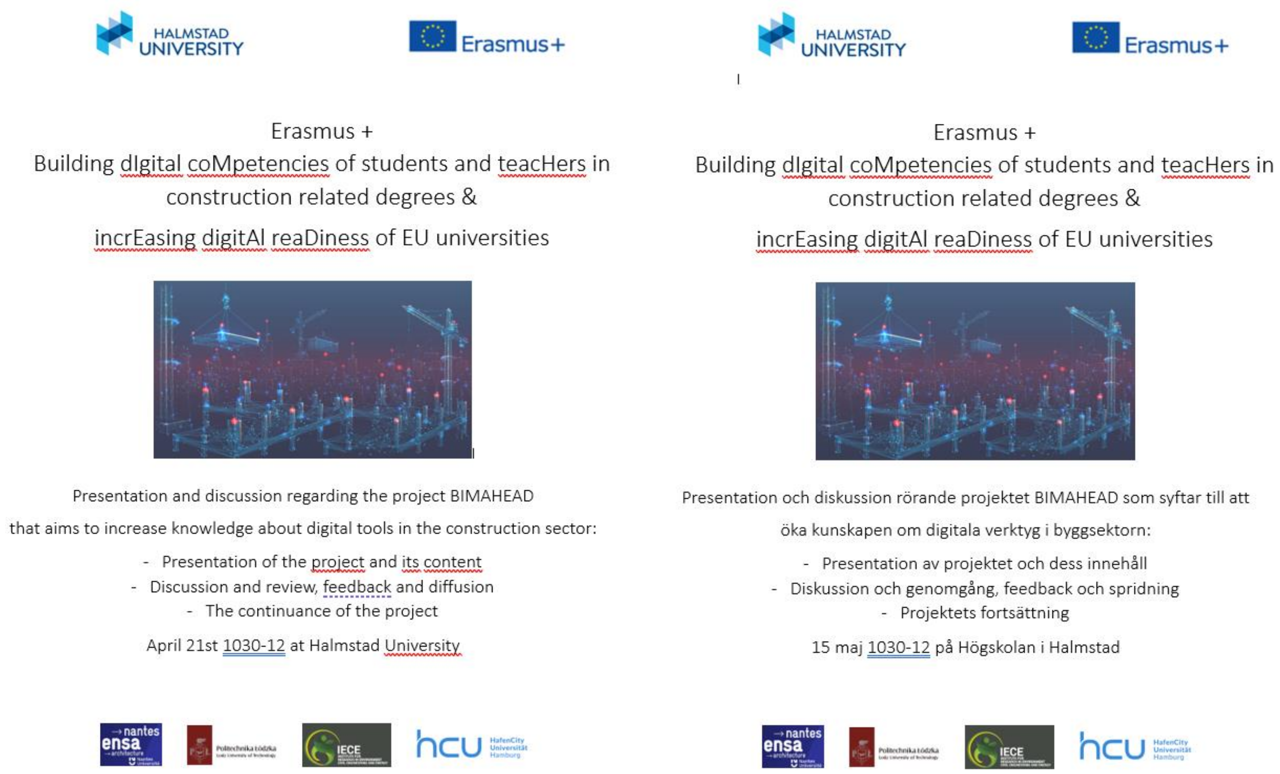

Fig. 4.3.1 Announcements of National Workshops at HH, Sweden

4.4 IECE Skopje, North Macedonia

Date of the National Workshop, place, number of participants

On March 28, 2023, a **National Workshop** was held at the premises of the Civil Engineering Institute Macedonia, where the results of the BIMaHEAD project were presented. 36 participants attended the event.

Workshops description

The workshop highlighted the importance of digital literacy and the need to acquire key digital competencies that are vital for future professionals in the construction industry (architects, designers, engineers, constructors, etc.).

BIMaHEAD facilitates the transition of the education system to distance learning and provides civil engineering and architecture students with access to online education with a specific focus on improving the digital skills of students through work in BIM.

Workshop scenario

The workshop started with an introduction to the BIMaHEAD project, and its goals presented by Pande Pop-Antoska. In this project an online learning program with 5 modules was developed. The module BIM Energy Calculation and Evaluation was presented by the trainer Dijana Likar and the other 4 modules were presented through short, recorded videos from their respective trainers.

After the presentation of the program there was an open discussion about the benefits of BIM.

Feedback from the participants

Participants were given a questionnaire about the importance of BIM and the benefits of online learning. When asked “Do you attend qualifying training courses”, 38% of participants answered that they sometimes attend qualifying training courses, 35% rarely and 17% Always. Regarding virtual reality in personal life or work, 40% or 63% of the participants answered that they never use virtual reality. When asked about using online courses for professional or personal purposes, 17% of participants say they always attend online courses for professional or personal purposes.

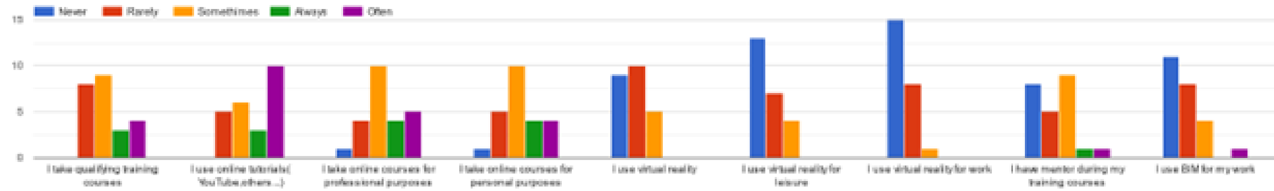

Fig. 4.4.1

Funded by the Erasmus+ Programme of the European Union

BIMaHEAD Erasmus+

Драги пријатели и соработници,

Задоволство ни е да Ве поканиме на **промотивен настан** на проектот „Градење на дигитални компетенции на студентите и наставниците за дисциплини поврзани со градежништвото и зголемување на дигиталната подготвеност на универзитетите во ЕУ – BIMaHEAD".

Настанот има за цел да обезбеди ретроспектива на проектот и да ги промовира резултатите од проектот.

Локација на настанот:
Градежен Институт Македонија
ул. Дрезденска 52
Датум и време:
28 март (вторник)
12.00 часот

Проектот се фокусира на развој на специфичните дигитални вештини за идните професионалци во градежниот сектор за креирањето на комплетен БИМ модел.

Го очекуваме вашето присуство,
Институт за истражување во животна средина, градежништво и енергетика

ensa nantes architecture · IECE Institute for Research in Environment, Civil Engineering and Energy · Lodz University of Technology · HCU HafenCity University Hamburg · Högskolan i Halmstad

Fig. 4.4.2

Fig. 4.4.3

Fig. 4.4.4

Fig. 4.4.5

Fig. 4.4.6

4.5 TUL Lodz, Poland

Date of the National Workshop, place, number of participants

The National Workshop at TUL was held on March 29, 2023. It was organised at the Institute of Architecture and Urban Planning, Lodz University of Technology, and attracted over 70 participants. A lecture hall and computer laboratories were used for the purpose of the event.

Workshops description

The National Workshop was intended to give an overview of the BIMaHEAD Project and provide hands-on learning experience with the aid of IT and exploration of the virtual world.

Workshop scenario

The first part of the National Workshop aimed at presenting the scope, process, and outcomes of the EU funded Project BIMaHEAD. Participants learnt about the institutions involved in the Project, the IO1, IO2 and IO3 outcomes, with more detailed focus on the content of the developed e-course. Besides, all five Modules syllabuses were presented, and dedicated online platform the course is to be available. The presentation focused also on BIM in general since the TUL team implementing the Project trusts that the digital competencies gained through BIMaHEAD will help promote highly skilled professionals in the AEC sector, which should contribute favourably to local, regional, national, and European economic development.

The second part of the Workshop started after the coffee break. It was provided in computer laboratories, which had all needed software and licenses installed earlier for the purpose of the event. Participants were given accounts and passwords to the laboratory network and to the Moodle platform. Special course being a mirror of the Clash Detection Module had been created on the platform for the purpose of the Workshop. Participants explored the Clash Detection Module at their own pace, with the assistance of BIMaHEAD team when needed.

At the end of the event, there were food and beverages that encouraged participants to express their opinions and discuss in a more informal environment.

Certificates of participation in the National Workshop were provided for participants.

Feedback from the participants

The first part of the National Workshop concluded with a vibrant discussion. Participants were interested in the course, its availability for testing and learning out of the university infrastructure, and also the possibility of awarding certificates on successful completion of the BIMaHEAD course as well as particular Modules.

The second part of the event was practice-based, and the feedback was immense in terms of the way participants interacted with the Clash Detection Module. The most engaging for them was to experiment learning process entirely designed in digital environment. Exploring examples of clashes in VR as well as interactive exercises were the most appreciated elements of the course.

Fig. 4.5.1 A welcome to BIMaHEAD National Workshop at TUL

Fig. 4.5.2 A presentation of the BIMaHEAD Project at TUL

Fig. 4.5.3 The practical part of the BIMaHEAD National Workshop at TUL

5 A report from the Final Conference

This chapter aims to provide a detailed explanation of the circumstances and reasons that led to the cancellation of the final conference scheduled for 25 June 2023. Initially, this section was intended to present the context and organisation of the final event, as well as the results achieved and future prospects, in an overview of the discussions held during the exchanges and presentations. However, due to recent events, such as the strikes and demonstrations linked to the pension reforms and the use of article 49.3 of the 1958 French constitution; as well as the questioning of the architecture teaching system and context by students and teachers of establishments under the supervision of the Ministry of Culture (ENSA, Beaux-Arts, etc.), it was decided not to maintain the event.

The final conference was to be a crucial moment for bringing together researchers, experts, and stakeholders to share the results obtained during the project and to discuss future implications, results, the question of dissemination, etc. In short, to present the research work carried out during the project and the results obtained.

Strikes and protests in France led to major disruptions, particularly in transport and in the administrative management of public establishments, which made it difficult for the planned researchers and invited guests to attend. Despite all our efforts to find ways of achieving our aims, it became clear that holding the conference under these conditions would have been compromised and would not have enabled us to achieve our objectives. On the other hand, the questioning of the teaching system by students and teachers in schools of architecture has created an atmosphere of uncertainty and tension within the academic community of schools of architecture. The demands and debates underway have completely diverted - and rightly so - the attention that might otherwise have been devoted to the final conference. Indeed, the issues raised by BIMaHEAD - although they may indirectly open the door to wider questions about architectural education - were undoubtedly not sufficiently frontal in challenging, or even rejecting, the practices and habits associated with the current system.

Consequently, noting the organisational difficulties associated with national movements, as well as the rejection by students and teachers of subjects that were not directly confronted with current local issues, it was decided, after numerous attempts to federate potential audiences and find administrative solutions, to cancel the final conference. At the end of the chapter, you will find the elements produced with a view to organising the conference in order to communicate on academic platforms and social networks, which attest to the desire to see the event through to the end despite the signs of difficulty that appeared as early as January 2023.

It was also decided not to postpone the event, in order to respect the concerns, agendas and preferences of all the partner institutions.

Cancelling the final conference was a difficult but necessary decision, given the current climate in France. In order to minimise the negative repercussions of this cancellation, we have decided to proceed as follows:

- Clear and transparent communication has been established with all partners regarding the national situation, and the decision to cancel the final conference will have been taken collegially after several discussions in the presence of at least one representative from each of the institutions.
- Although the final conference will not be held, it is important to recognise the importance of continuing the discussions and exchanges on the fascinating subjects raised throughout the project. We have decided to continue sharing ideas, discoveries, and perspectives through other channels, such as seminars and regional meetings.

Fig. 4.5.1 Website dedicated to organizing and sharing information on the event. https://bimahead.sciencesconf.org/

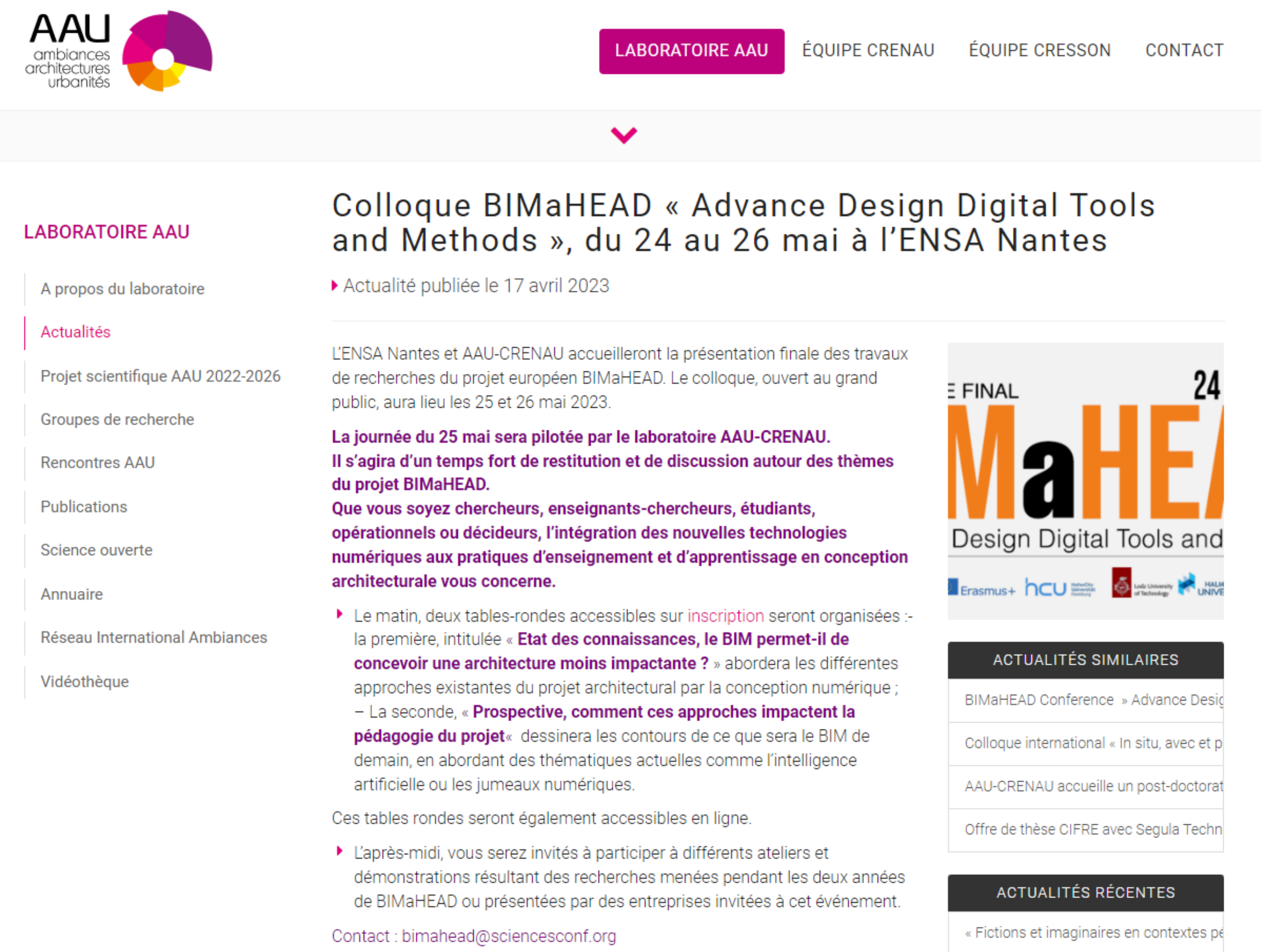

Fig. 4.5.2 Publication on the AAU lab website

Fig. 4.5.3 Communication support displayed on various screens at ENSAN. Declined in posters and supports for social networks.

6 Evaluation of the final outcomes of the BIMaHEAD Project

6.1 ENSA Nantes, France

The main obstacle we thought we had to overcome at the beginning of the project was the independence of the content from the provider. One of the key points of teaching is the proximity and direct communication between the student and the teacher, and even if the tutorials are trivialized, they must be thought through considering all the possible misunderstandings and prerequisites needed to complete them. A second – more purely technical – challenge we felt we had to face was the transition from the learning platform to the potential experience of the student's work in VR, considering that this is a more unusual use in architectural learning and often involves the need for direct guidance.

In the end, thinking of each tutorial as a finished product that did not require a teacher to follow was a challenge that was more exciting than difficult, and provided a guideline for what could and could not be done. On the other hand, as expected, the most complex thing was certainly to find a workflow that made the transition to virtual reality, since there are both a multitude of platforms that exist, and no preconceived link that really meets our needs.

The team is composed of 6 people:

Firstly, Laurent LESCOP as scientific director. Experienced architect and specialized into CG graphics and immersion, he is a trained specialist for 3D scanning, modelling, and restitution in the fields of archaeology, architecture, and scenography. His main teaching and research refer to immersion and immersive devices used for design and visualization.

Lobo RAVELONTSALAMA, head of the international department, in charge of the organisation.

Rima AYOUBI, PhD student focusing her work on the digital restoration of a heritage ambiance through the example of the souks of Beirut.

Arpi MANGASARYAN, PhD student specialized on digital generative tools for in architecture in an architectural lab and with the emergence of Artificial Intelligence.

Marie-Pierre DUCHESNAY, Marianne-Eva LAVAUR and Théo GERMAINE, as part of their end-of-study internship, working on various aspects on the project, from helping with research to participating in the communication process.

The search for form is a key stage in architectural design. It determines all the technical and aesthetic choices that will follow and will condition the price and performance of the building. In BIMaHEAD's proposals, the search for forms will be based on an algorithmic approach that will allow complexity to be introduced. This complexity will then lead to the early consideration of environmental data and consequently, to propose a sustainable and environmentally friendly design.

Upstream of the search for forms, there is therefore a search for environmental and contextual data. Then, algorithmic sketches will integrate structure, price, and energy performance. The form search module therefore introduces the themes of the modules that will follow in the rest of the course.

The students are confronted with an approach that is different from the usual project practices. The form research module forces them to create tools that correspond to their project intentions, whereas traditional approaches lead them to learn and adapt to a pre-existing tool. It is therefore an approach that encourages innovation, initiative, and independent thinking. It is obviously more complex, but it is a good introduction to the current digital revolutions of generative design and artificial intelligence.

The module invites an extension in virtual reality. Virtual reality allows you to be immersed in the project and to see it as it will be seen once it is built. The idea is therefore to propose methods and solutions for continuing to sketch in real time and in immersion. This practice also prefigures the evolution of design practices.

The project will have enabled the acquisition of various skills on several aspects. It developed our abilities in parametric modelling, but also and above all on the ability to synthesise this knowledge to restitute it in the most comprehensible way possible to unexperienced trainees. It allowed the team to acquire knowledge on more advanced aspects of the pedagogical possibilities offered by VR, and on the diverse opportunities that exists for providing content through VR. However, the main thing we learnt through the project is the opportunity to really shift the way we use to teach digital skills in the architecture learning journey, from a face-to-face method to a side-by-side collaboration.

From the learner's point of view, the modules invite the discovery of methods and techniques that are different from those found on the Internet or in textbooks in that they answer conceptual questions and not technical exercises. The connection with real situations is therefore more obvious and more immediate. It is also easier to transpose the proposed solutions.

From the teacher's point of view, the proposals seek to modify the conditions of learning. By mobilizing algorithmic methods, two learning scenarios are set up. The first encourages autonomy and personal research. It starts with a closed question that opens into numerous propositional ramifications. The evaluation is therefore based on the learner's capacity for autonomy. The second scenario envisages learning with the tutor. In this case, it invites the creation of an exploratory approach and therefore teaching side by side rather than face to face. The idea is to develop an enriched questioning process co-constructed by the teacher and the learner.

SWOT:

Strengths of the Project results:

- Complete course on parametric modelling with Grasshopper, from basics to advanced concepts.
- A teacher is not needed to provide the course.
- Courses can be followed at your own pace.

- It is easy to translate the courses, or to follow them with basic understanding of English.
- Only uses software that is free to use/open source or with academic licenses provided.

Weaknesses of the Project results:

- Not always the clearest on explaining choices made despite the explanation of the process.
- Rely on a diffusion platform (Moodle).
- Depends on software that can be difficult to learn at first.

Opportunities of the Project results:

- Interest at European level to develop global courses for all countries.
- Context of exchanges and participation in clubs of professionals from the educational or digital field.
- Investment by various French higher education institutions: schools of architecture, universities, etc.
- Interest by the region in developing online and digital education content in its area.

Threats of the Project results:

- Not obvious to integrate in an existing educational ecosystem or to adapt it to a programme.
- Software evolves rapidly so courses are not necessarily suitable over time without changes.
- Hosting courses requires the allocation of dedicated servers which can be costly.

6.2 HCU Hamburg, Germany

Barriers to overcome before the start of the BIMaHEAD Project

After the initial analysis phase, it quickly became clear to us that we wanted to convey our teaching content in a computer game. However, we did not have any infrastructure for this within the university framework, neither specialists, nor software, nor external expertise. We had to orientate ourselves quickly in this new subject area, gain an overview of software that corresponded to our competences and decide on a product without long comparisons and test phases. Nevertheless, we spent time on this phase, which was not foreseen in the project, and we did not really make up for it until the end of the project. In the end, we chose the SimLab software because it allows us to create virtual spaces in which participants can interact (Interactive VR) without any coding knowledge.

Challenges faced during the Project

Unfortunately, we also learned about the limitations of the software. The promised Moodle integration via Scrom did not work and we had to readapt the Moodle platform. During the test phase, programming errors came to light which we fixed, and it turned out that our room, or rather the movement in it (changing lateral head movement with VR headset) led to feelings of nausea in some participants. Therefore, we had to completely redevelop the room and the action scenario in the room (relaunch). Basically, the software is not as graphically performant as the market leaders Unity and Unreal Engine, but it gets by with far fewer human resources and programming skills (coding).

Description of the Partner's team

Our team consisted of the project leader, Professor Bernd Dahlgrün, and tutors with programming skills who programmed the virtual rooms (Dominik Diehl and then Helmut Teuber Alba). The Moodle site, as well as the implementation of the virtual rooms in Moodle, was also done by student tutors (Jasmin Drutjons and Felix Görrissen). The organisation of the project was done by a research assistant (Clemens Braun).

Innovative pedagogy

The didactic approach of our BIMaHEAD project is innovative in two ways:

Gaming: the teaching content is conveyed in a 3D computer game. In this way, the participants succeed in acquiring spatially shaped knowledge and competences in a low-threshold and effective way alongside their jobs, studies, and everyday life. All participants attest that the exercises are fun and increase their knowledge. And fun has always been the best teacher!

A stimulating dual-track approach: the exercises teach constructive knowledge, namely the form of the components and their successive assembly, as well as the modelling of these components in a BIM model. The constructive knowledge is the basis for consistent BIM models, the modelling itself sharpens the constructive knowledge. Both areas are mutually dependent and enable the participants to acquire modelling and construction skills simultaneously.

Self-assessment knowledge achievement

In the VR rooms, theoretical knowledge regarding spatial-temporal phenomena was visualised for the trainees, or this knowledge was acquired by means of experimental action. The effective communication of these spatial and temporal relationships was confirmed by most of the trainees. For some participants, this was a new form of knowledge and was perceived as an "aha effect". For all trainees, this was a knowledge gain that complemented their constructive knowledge with spatial references and temporal processes like a puzzle piece.

Learning experience of the trainees

All participants enjoyed the exercises and successfully passing an exercise was perceived as a sense of achievement. The participants cooperated strongly and helped each other. The knowledge gained was considered applicable and complementary to regular courses.

An analysis of the online teaching practice from the point of view of the teaching staff

SWOT:

Strengths of the Project results

- Low-threshold learning through gaming
- Didactic effectiveness
- Constructive foundations for consistent modelling of 3D models
- New form of effectively imparting spatial knowledge and acquiring spatial competences

Weaknesses of the Project results

- System vulnerability (unstable software)
- Consistency of the hosting platform
- Opening of the teaching platform
- Lack of/weak gaming skills among university staff

Opportunities of the Project results

- Can and should be expanded in terms of content
- Provides globally applied and needed competencies
- Can and should be expanded and opened for worldwide use
- It could develop into a didactically highly effective, globally accessible, and globally used teaching platform after further content expansion and constantly optimized game environment.

Threats of the Project results

- Software dependency: If the software were to be discontinued, the project could not be further developed.
- Resources: If no sponsors or budget funds can be found for the project in the future, the project will not be developed further at the necessary speed.
- Commercial providers develop graphically highly developed computer games with the same teaching content (idea copy) with much greater resources and coding skills.

6.3 HH Halmstad, Sweden

The project has resulted in a new module to be used to increase BIM maturity and diffusion. By using new combinations of innovative and traditional pedagogical tools, new forms of knowledge diffusion have been achieved. The module provides a baseline within different modules that can be added to existing efforts to teach and train on BIM. The first part, with recorded lectures and quizzes, leans toward a more traditional way of teaching. These methods were found to be more suitable to deliver theoretical knowledge. Yet these conventional forms of teaching are combined with a gamification approach promoting trainee retention in the absence of extrinsic motivation factors also in this first part of the module. The second part, the software demonstrations, has created new way of teaching software proficiency. Consequently, it has enabled new ways of demonstrating the benefits of a software-based approaches.

The learning experience has met the projects expectations. The module provides a basis for digital calculation and cost estimation that different universities and other European educational institutions, including professional training, can use in their more extensive educational and training programmes. The module has been received well by stakeholders within the educational and training sectors and are described as relevant according to those stakeholders. The module provides a new combination of traditional and new pedagogical tools & methods providing a new experience for the trainees. The module delivers content which participants has described as expected and appropriately delivered.

The module created by Halmstad University is set to operate without ongoing support by teaching staff. The workload for the teaching staff is thus dominated by pre-course activities such as pre-recording lectures and preparing assessments. The course is, in that sense, familiar to teaching staff. This conclusion does not restrict teaching staff of working with supporting materials, modules and the broader setting of the module was a teacher has broad opportunities to bring his or her innovative contributions to the overall learning experience. The work was initially conducted by members of the construction engineering group I e Johan Lind (MSc) Yahya Ghasemi (PhD), Mohsen Soleimani Mohseni (PhD), John Lindgren (PhD), Robert Ågren (MSc) and Kristian Widen (PhD). The latter part of the project has been conducted by John Lindgren (PhD) and Robert Ågren (MSc) with the aforementioned staff working as a group of reference.

SWOT:

Strengths of the Project results

- The project results provide easily accessible content.
- It serves as a solid foundation for further development.
- The project can be disseminated and implemented across Europe.
- It demonstrates the process of digital calculation.
- It integrates costs aspects with climate data aspects.

Weaknesses of the Project results

- The platform may have technical vulnerabilities and may be unstable.
- Portability issues exist between hosting platforms.
- Portability issues, and reusability issues with pedagogic material.

Opportunities of the Project results

- There is potential to expand the project's topics.
- It offers globally applicable and essential competencies.
- From a technical perspective it can be expanded and made available for worldwide use.

Threats of the Project results

- Software dependency: The project's progress is dependent on specific software, and discontinuation of the software could hinder further development.
- Resources: Securing sponsors or budget funds may become challenging in the future, affecting the project's pace of development.
- Commercial providers with greater resources and coding skills may develop similar teaching content, posing a threat of idea replication.

6.4 IECE Skopje, North Macedonia

Barriers to overcome before the start of the BIMaHEAD Project

Lack of awareness of benefits and impacts of application of BIM tools for improving energy performance of buildings, identified at professionals and students, was recognized as the main barrier to be overcome in the course of the BIMaHEAD project.

Challenges faced during the Project

The main challenge was to explain the switch from traditional CAD design towards 3D BIM modelling, using thereby the method of comparison, and specifying advantages.

Description of the Partner's team

The team consisted of a technical expert (Mrs Dijana Likar), an educational expert (Prof Dr Angelina Taneva Veshoska), an analytical expert (Ms Ana Tomik) and an analytical and module design expert (MSc Pande Pop Antoska)

Innovative pedagogy

Innovative aspects of the applied pedagogy included: Presentation of a generic workflow of development of a building, energy model, including guides for steps and checkpoints, to ensure correspondence to architectural model and basis for optimization of design alternative; replicable in other BIM software environments.

Self-assessment knowledge achievement

Self–assessment knowledge achievement provided more than satisfactory results. The results achieved by taking quizzes were over 80% of the average score.

Learning experience of the trainees

The trainees positive learning experience during the course training and assessment (a post – course survey capture of opinions was carried out).

6.5 6.5 TUL Lodz, Poland

Barriers to overcome before the start of the BIMaHEAD Project

Due to the times of COVID pandemic, the barrier to overcome was to assemble a team and proceed with administrative issues.

Challenges faced during the Project

Because of BIMaHEAD's comprehensive approach to BIM teaching topics, we encountered all sorts of cross-cutting problems in the project. Initially, the challenge was to create a database of available BIM courses and collect their descriptions to enable their comparison. At our university - Lodz University of Technology - there are syllabuses of the courses taught, available in both Polish and English. This gives knowledge of the course content, teaching methods, learning outcomes. This was a reference point for us in our search for other materials, but it was relatively difficult to find analogous data at other universities. In this regard, the biggest challenge was the COVID pandemic time that made getting in touch personally with other universities or training centres in Europe impossible. Therefore, the methods of searching and collecting data were limited.

In the next stage, we researched the general subject matter of BIM. Although our team included members associated with both the teaching of BIM and the practical application of BIM, the challenge was to break down the BIM subject matter into smaller, thematic modules. It was also a challenge to study aspects related to BIM but not directly related to the software being taught, such as: principles of application, project planning, BIM information exchange, classification systems, standards, and directives. In addition, the modules were set up in a logical sequence representing a development path for someone starting to learn with BIM. Some modules were too large, so they had to be divided into several smaller ones, and some were incorporated into larger, thematically related modules. Another problem was to define "personas" i.e., diverse types of BIM specialists prepared for distinct types of tasks, such as modelling, design supervision, coordination. We wanted to create the course using the idea of gamification, differentiating it from standard courses in the form of tutorials. Another problem was the distribution of topics to be developed among the BIMaHEAD Project Partners. Due to the size of the Project, it was not technically possible to develop all the modules proposed initially, so we had to select a few, but also tie into a course that would form a logical whole and cross-sectionally show different applications of BIM. Finally, the BIMaHEAD Course consists of five Modules. Polish Team selected the Clash Detection Module, so we started the task with comparing and selecting the programs to be included in the course. By overcoming this barrier, we gained a broad knowledge of the available programs and, above all, the possibilities they offer. After selecting the programs, we were faced with the problem of choosing the platform on which the course would be held and the form of interaction with the user. The choice fell on the Moodle platform and Spatial. The course should be largely unmanned, that is, it should allow the user to perform successive tasks, but at the same time check the progress made. Therefore, we chose interactive video, which gives access to further content only after the correct answer is obtained.

The challenge was also a platform containing text and video materials. Initially, a platform lent by a Partner from Germany was used, but with the need for internal testing, this required inter-university coordination regarding access from one university to the other university's system. On the scale of the BIMaHEAD Project, a server with appropriate software to allow access to a wider range of users was also an issue.

Description of the Partner's team

At the time of the BIMaHEAD Project, five people participated in the work of the Polish team. Initially, the team consisted of three people associated with the practical teaching of BIM to architectural majors (Anetta Kepczynska-Walczak, Karolina Drozdz, Agata Glinkowska-Musialek) and one person teaching civil engineering students (Artur Wirowski). After the initial stage, a civil engineer stepped down and an architectural engineer joined the team (Michal Jarzyna).

At a later stage of the work, in a team of four, three people were also associated with BIM through diverse types of scientific research conducted in this field. The team leader, Anetta Kepczynska-Walczak, is the eCAADe Council Member (the international organization related to education and research in computer aided architectural design in Europe). Among the team members is a doctor whose PhD thesis focused on BIM, and a doctoral student whose dissertation is related to BIM. All team members have practical design knowledge and experience with the use of BIM in design.

Innovative pedagogy

The innovation of the course was the use of self-study methods in the form of an online course based on written materials and videos, while introducing gamification and a unique way of user interaction with the course. This was the control of an animated character in a 3D world allowing the user to independently explore the prepared environment, analogous to various types of third-person perspective computer games. The knowledge of possible collisions in buildings was presented in the form of an interactive three-dimensional exhibition allowing the user to observe a problem from different sides and learn about it in the description. Links to further video tutorials were hidden in the building and its surroundings. From observations made in testing the Clash Detection Module with students, this was very interesting and engaging for users.

Self-assessment knowledge achievement

The knowledge gained by studying provided materials on clash detection theory (named Book of Clashes) is tested in the form of an online test demanding answers in the form of closed-ended questions. Thanks to this, the system compares the answers with the template and the user is informed in real time about the correctness of the answers given and the possible need to repeat the theoretical part of the Module. The practical part includes video tutorials in the form of interactive H5P videos. When an activity in the program is presented during the video, the video stops on its own and a task in the form of a closed-ended question appears on the screen. The user has to perform the task himself to answer the question. If the answer is correct, he can continue learning, and if the answer is wrong, the video is reversed, and the activity is presented again. As a result, it is not enough to just watch the video carefully, but the user must also perform the activity. Only the correct answer lets the user through further.

Learning experience of the trainees

Users are introduced to the theory of clash detection in an attractive computer game and interactive videos. For users, especially young ones, moving a character around the 3D world is a form well known from computer games. The Module can be done at the user's own pace, which gives users added comfort. Apart from installing student versions of the programs taught, the Module has no additional requirements, so it is affordable for users. The videos are narrated using text-box descriptions, so there is no need for speakers or headphones. This also reduces the possibility of misunderstanding the pronunciation or accent of the lecturer, which is often a drawback of courses available online.

An analysis of the online teaching practice from the point of view of the teaching staff

The Module is largely maintenance-free, that is, it requires no teacher involvement. Knowledge and skills are delivered via text and video, and answers in the form of closed-ended questions are reviewed on an ongoing basis.

SWOT:

Strengths of the Project results

- explanation of important BIM issues,
- self-learning method,
- Innovative interface,
- user activity required,
- no need for teacher involvement.

Weaknesses of the Project results

- questionable usefulness of the tutorials in a few years' time due to software change,
- the need for computer equipment and good internet connection.

Opportunities of the Project results

- development of the Module to explain additional clash detection programs,
- expansion of the virtual world.

Threats of the Project results

- non-self-reliant performance of tasks,
- the possibility of getting stuck on one task while not asking questions,
- evolution of the software, especially the software interface, which may create differences between video tutorials and current clash-detection software version.

7 Recommendations and guidelines for replicability

The BIMaHEAD e-learning and self-assessment course consists of five specific BIM Modules developed individually by each Partner of the BIMaHEAD Project. Each Partner has brought different expertise and experience to the Project. Moreover, the profile and scope of each Module developed by each institution resulted in a variety of observations and conclusions. Therefore, this chapter presents recommendations and guidelines for replicability from the perspective of each Partner. By that, it brings more valuable and specific input as an outcome of the BIMaHEAD final result.

< ENSA Nantes, France >

The main recommendation for replicating the project and its content in another time or geographical context is to pay close attention to the questions you wish to answer through the implementation of the content: What do you as a research group want to know, but also what does the content need to be able to provide to students? These questions will really define the shape of the course, and will allow to develop it in a privileged direction according to the feedback of the different students via the forms they are asked to fill in.

The questions that seem to be essential are those of the time spent by the student on each of the different exercises, completed by the prerequisites necessary for the completion of this exercise.

We realize as we test the different exercises that there are "holes" in them, which we don't even realize when we do them because our prerequisites are not the same as those of the students, but also that the average time of completion is much higher than the one initially envisaged. It is therefore of primary importance to study the prerequisites necessary for each of the exercises, and to adapt them as we go along so that as few prerequisites as possible are necessary. As for the question of time, it is completely related to the previous one. Thus, the more the prerequisites are acquired, the lower the completion time is, so it is a powerful indicator of success of an exercise or not, which should certainly not be neglected.

If one were to define a few particularly important guidelines for successful replication of the project, there would probably be 5 major ones to consider. First of all, if we don't know who will be attending the courses, it is crucial to think about them in terms of this unknown parameter: we must consider that the content must be accessible to all levels and build the program with an ascending difficulty as we complete it, starting from a minimal prerequisite level to reach an advanced level.

Then, it will be necessary to make sure that the courses are completed by students of various levels in order to consider their feedback and to be able to modify the content according to them.

It is also important to think that the platform on which the content is broadcast is an integral part of the course, so it should not only be a medium for transmitting pre-existing knowledge but should also allow for interaction and dynamism: questions between the steps of an exercise, for example.

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Finally, and to go a little further in the exploration, it is quite quickly necessary to realise that a paradigm shift can take place from the point of view of pedagogy. Indeed, if the courses could be followed alone as simple tutorials, it is the presence of the group and the teacher, and in particular during the passage in virtual reality, which transcends the exercise and makes us pass from the instructive mode to the collaborative mode. The teacher and students are no longer face to face but side by side in the learning exercise. This point is crucial because it is the latter that brings about a real innovative interest in the way digital courses are delivered in architectural education, so it is essential to persevere in the perspectives it opens up.

< HCU Hamburg, Germany >

Project Review

The BIMaHEAD Construction Module is a digital tool that can didactically convey spatial and temporal relationships in a highly effective way. The possibilities offered by this tool are much more efficient and low-threshold than the usual language- and image-based university teaching formats such as lectures, seminars, or exercises. Language barriers do not play a role in BIMaHEAD -Construction or are gradually broken down by learning technical terms along the way. With this tool, it is possible to reach people outside of the established teaching institutions who are far removed from education and to bring them teaching successes. Moreover, the BIMaHEAD-Construction module is accessible at anytime and anywhere in the world. Embedded in other teaching formats, the module can close didactic gaps in teaching spatio-temporal phenomena (such as assembly processes = processing objects in a certain logical order).

On the other hand, the creation of such a module goes hand in hand with a high technical effort, which requires competences and resources that the usual teaching institutions do not have. Indirectly, the module competes with computer games, whose graphics, scenarios, and action patterns can be better developed with more resources. Considerable human resources with specific coding skills are needed to develop computer games with performant and competitive programmes such as Unity and Unreal. These resources are not available to institutions like universities. For this reason, in our experience, only a low-tech variant of a computer game can be created in a university setting, with the didactic output determining the quality of the game. The module will never reach the entertainment level of a computer game, but it has the qualities to make it possible to experience spatial-temporal phenomena in short sequences in addition to common teaching formats.

Recommendations

However, this is only a current inventory. It is to be expected that the programming possibilities and graphical qualities of the programmes will continue to develop and thus become easier to program (no coding knowledge, use of AI) and with fewer resources. The BIMaHEAD Construction module was ultimately developed with a "low-tech" software (SimLab) whose capabilities and output qualities are significantly behind the game standard. However, this tool was effectively usable in the project timeframe with our resources and skills. The participants found the exercises to be didactically very efficient, knowledgeable and low-threshold as a supplement to their university input. Therefore, we recommend the development of such tools in the university context, in the justified hope that virtual 3D teaching spaces can be created less resource-intensive, easier, and faster in the future. No other didactic tool known to us can convey spatio-temporal phenomena as efficiently as 3D teaching spaces. These can thus be an effective compensation for the lack of practical experience.

Guidelines

Human resources:

The creation and maintenance of the BIMaHEAD Construction modules requires specific expertise and competences:

- 1 person responsible for the didactics, designing the exercises and integrating them into other teaching formats.
- 1 person responsible for the Moodle implementation and managing the Moodle server structure
- 2 people to programme the virtual rooms

These personnel resources should be permanently available for further development, maintenance and updating of various software updates.

Process guidelines:

1. In order to make the design process of such 3d teaching spaces as efficient as possible, we recommend clarifying the following aspects before starting the Project:
   a) What other teaching content is to be supplemented by BIMaHEAD?
   b) Where do spatio-temporal phenomena need to be understood within these teaching offerings?
   c) What exactly are the objects and processes of the phenomenon? - Visual representation of the phenomenon.
   d) Collect all relevant phenomena and represent them in the same way.
   e) What regularity/similarity is inherent in the phenomena to be represented virtually?
2. In order to make the creation of the VR rooms efficient, we recommend:
   a) To create uniform rooms for a uniform form of exercise (room templates).
   b) To create programming templates for repetitive interactions and processes.
3. At the same time as starting the project, we recommend purchasing the server structure for the future virtual 3D modules, as this also requires longer planning and procurement.
4. Start of the project
   a) Draw up a project schedule.
   b) Commit personnel resources.
   c) Creation of the templates in the first VR room.
   d) Test first VR room (see below).

   - e) Optimisation of VR room / templates.
   - f) After finalisation of the first room / templates, creation of the remaining rooms based on the templates.

5. Quality control: the didactic effectiveness and the usability of the modules can only be verified by project-experts.
   - a) Therefore, we recommend several test runs with participants from outside the project.
   - b) Each test run should be analysed, and optimisation measures identified.
   - c) After each test run, the project schedule must be adjusted for optimisation.
6. Relaunch
   - a) Implementation in Moodle or similar. teaching portal.
   - b) Test with partner institutions.
   - c) Promotion, elaboration of interfaces to other institutions (linking).

< HH Halmstad, Sweden >

Regarding replication of the project a major learning is to acknowledge contextual differences by participating parties, although we see that the parties have complemented each other in terms of working and move forward.

Regarding the courses developed, we see that the end result regarding the level and the prerequisites for the course(s) are on a good level and that these types of courses should strictly be aimed at introducing different types of methods, areas and software. However, since university students have been the major testing group it would be of significance to take other groups into account in the testing, not just students of various kinds, but also professionals. This is however an issue to consider in the continuance of the project and requires a bit of additional supportive work. We have however seen that the modules provide a basis to build further on, for diverse kinds of groups. The modules also require updates, but with the project ending, this will have to take place within the work of ongoing courses. This ongoing development will also require us as developer to keep up with the current development within digital teaching.

A major lesson during this project is to keep each module subjectively relevant for the learner. While the gamification approach used in BIMaHEAD is relevant, the experience from the project is that focus on intrinsic motivation is the key to achieve trainee retention for the complete set of courses. The gamification approach can be achieved with using LMS features such as badges and grade rewards. But this kind of incentives is not in their self-enough to achieve retention. Thus, the modules must be clearly relevant for the learner from the start. The term relevant needs to be approach subjectively from the perspective of the learner. As a consequence, there is a need to clearly explain the purpose, goal and takeaways for each module.

For a continued project, we see that a palette of different skills is needed besides the construction management knowledge, such as digital teaching, digital tools, implementation of digital tools and digital design, since these have been identified in the work conducted in this project. We also see that the content needs to be developed continuously in line with developments within ICT, pedagogy, and software-development. In the platform available, there are also possibilities to add content as long as the authorization and authority is available. If real examples are to be used, of course this also requires software availability. Another important issue is that the modules keep being self-maintained, so that the modules can run smoothly, but with a user survey in the end of the module to support future development. As is today, a certificate automatically generated upon finishing of the course should stay as it is.

< IECE Skopje, North Macedonia >

Recommendations

Further improvements will be made towards tailor-made variants of the module, applicable for a wide range of specific target groups of learners.

Guidelines

The modules were created to be applicable and useful for a wide range of target groups – students, professionals, public administration, construction site managers, etc. That provides a basis and opportunities for further replication. Pre- condition for use of the modules Is the requirement for skills in BIM 3d architectural modelling.

< TUL Lodz, Poland >

Recommendations

The first recommendation for conducting analogous research and development work in the field of remote learning of software, prior to the start of practical work, is that the course should have its own dedicated server with technical support services. The server should have a Moodle (or similar) environment for remote teaching, as it is an open-source platform. All Partners create their content based on the given environment and ensure that the materials created are compatible with the version of Moodle installed on the server.

Apart from an open-source hosting platform, in order to ensure the inclusiveness of the course, it should be based on software available in free versions and with guaranteed availability for at least 5 years.

As the course by intention should be accessible to students from different countries and adaptable to diverse types of learning modes, it should be self-sufficient i.e., not requiring ongoing maintenance by the teacher and the need to check students' work. This allows students to get immediate feedback on their work and reduces the cost of maintaining a functioning course.

Tasks to be completed in the course should require active user participation. Thus, the possibility of passive participation should be excluded and the possibility of unassisted performance of tasks should be minimized.

Students should be able not only to receive feedback on their work but also to provide an opinion on the course itself, which should be reviewed periodically by a dedicated "course tutor" for possible improvements.

It is worthwhile for the course to also include a self-certification system that automatically generates a dedicated confirmation upon successful completion of assignments.

Guidelines

- Course content migration:

  The course can be archived and transferred between Moodle environments. For optimal performance, the content should be transferred to Moodle in the same version in which it was created and tested on the server of the Partner from Germany.

- User requirements:

  It is important to check the requirements of each BIMaHEAD Module individually since they differ due to the specific focus of each Module. In order to properly participate in the Clash Detection Module from the user level, the following are required: a computer with Internet access, educational versions of Solibri Model Checker and ArchiCAD, knowledge of structural engineering regarding the basics of building construction and the terminology used, BIM basics.

- Application of the course:

  First, the Clash Detection Module can become a complement to the classes taught at the university. On the one hand, self-learning methods are then used, and on the other hand, a student has relatively easy access to a supervising teacher in case of doubt. Secondly, it can serve as an independent online offer, accessible globally. Besides, the interactive form of the Module as well as working in own pace and time are attractive to young people. The Clash Detection Module can also become training material introducing clash detection issues in industry.

Summary

The Partners report several issues encountered during the execution of the project. Certain problems stem solely from individual Partners, whereas other aspects are more or less relevant to all the Partners involved. This is a summary of the issues which has been identified by all Partners.

The Partners have highlighted the significance of acknowledging the prerequisites for the Modules, and they have approached this matter in various ways. The primary perspective has been to maintain the Modules' simplicity, but it is essential to possess construction knowledge in order to maximize their effective delivery. There are also technical prerequisites affecting most Modules to a certain extent. Access to appropriate software is the most prevalent prerequisite among the Modules. While it can be expected that most AEC-professionals has access to the required or recommended software, the access for students are more restricted. Students generally must rely on trial licenses, or in some cases, student licensing if the student aren't enrolled at a university with campus licenses. Nonetheless, the BIMaHEAD e-course and all its Modules are available and applicable to the public. The Partners report that the Modules support the traditional teaching in university courses but also accents that the possibility to access the Modules for free and anywhere in the world further strengthens the use of the courses. The Partners report that the course is viewed as a steppingstone for developing further courses on BIM, both for their own institutions, but also for other institutions. Moreover, the existing Module design, which includes an automated course certificate upon course completion, is considered an essential feature as it facilitates the scalability of the course.

The Modules themselves can and should be developed further. Development areas are constantly found in the Modules, both in terms of quality but also in subject scope. Since the BIMaHEAD Project is ending the main driver for such development is as a part of ongoing educational development at the Partners' institutions. To facilitate continuous development, each Module has integrated course evaluations attached to them. Furthermore, there is a requirement to appoint a course administrator responsible for development for at least the next five years. Considering the progress made in the development of the courses, there are several significant areas of knowledge required. Primarily, construction knowledge is essential, along with expertise in digital education encompassing course design and technical aspects. Additionally, having knowledge of game design would greatly contribute to the development process.

A key lesson for future projects is to conduct a thorough review of the digital platform at an early stage and ensure its availability and functionality. Establishing and implementing this platform requires more effort than anticipated, as it necessitates support and proficiency in multiple aspects, including technical assistance and adequate funding to ensure its continuous operation.

8 Appendix: multilingual versions of syllabuses

Here is the set of tables with all syllabuses prepared in English and translated into BIMaHEAD Partners' languages: French, German, Swedish, Macedonian, and Polish. As a result, there are five syllabuses in six languages in total (including English) reflecting five BIMaHEAD Modules that present the content of the BIMaHEAD e-learning self-assessment course.

Table 8.1 BIM Form Finding from Environmental Constraints Module Syllabus

Title of the Module	**BIM Form Finding from Environmental Constraints**
Type	online
Workload (hours)	20 hours
Institution(s)/Author	Ecole Nationale Supérieure d'Architecture de Nantes
Prerequisites	Students and professionals with basic knowledge on modelling and environmental phenomena
Content/short description	**Form Finding for a Better BIM Project** Integrating climate phenomena early in the architectural design process is crucial for their proper consideration. Algorithmic methods make it possible to incorporate complex and dynamic climate phenomena, resulting in forms that are better suited to climate constraints. This module employs virtual reality to immerse designers in the heart of the creation process. a) Methodology • Incremental teaching through exercises of increasing complexity • Self-teaching at each own pace • Possibility of tutorial teaching b) Goals • Better definition of the design objectives • Better definition of the design process by identifying each step • Use of climate data from world data base • Design process that allows generative design to open up more alternatives • Use of VR for a better immersion in the design process c) Issues

	• Better design to slow climate change • Integration of multiple inputs • Design by environmental constraints • Multiple results to be evaluated d) Specificities • Methodology learning more that software learning • Complex problem solving • Easy connection to BIM software **Innovation** The course introduces a novel design process by suggesting a methodology that includes data collection and designing intricate shapes while considering climate constraints. The resulting designs are then evaluated in virtual reality on a communal Metaverse platform, allowing for a seamless transition from design to project communication. This innovative design paradigm focuses on exploring a range of solutions that meet various constraints through the use of algorithmic and generative design methods. The integration of virtual reality introduces new avenues for evaluating project results and facilitating communication.
Learning Outcomes	**Skills** acquired • Rhino Grasshopper (algorithmic design) • Ladybug for solar paths and energy calculation (climatic simulation) • Galapagos (generative design) • Unity (real time VR applications) **Knowledge** acquired • Basic climatology principles • Ambiances and comfort • State of the art design tools and methodology
Learning materials (e.g. exercises, data sets)	Tutorial with step-by-step progression. Multipath guiding to illustrate design alternative, outside references to enrich the content, content evaluation. Hardware requirement: computer with minimum graphic and RAM power, internet connection, VR headset optional.

Language/s of instruction (oral and written material)	English
Method/s for teaching and learnings	Presentation of a generic workflow of development of a building, energy model, including guides for steps and checkpoints, to ensure correspondence to architectural model and basis for optimization of design alternative; replicable in other BIM software environments.
Method/s of assessment	Quizzes and multipath workflow that evaluates the process' understanding.
Method of course evaluation (by students, peer review etc.)	Questionnaire, Moodle anonymous feedback

Table 8.2 BIM Modelling Module Syllabus

Title of the Module	**BIM Modelling**
Type	online
Workload (hours)	10 hours
Institution(s)/Author	HafenCity University, Hamburg; Architecture Department
Prerequisites	Students and professionals from the AEC sector

Content/short description	**Elaborating BIM Models (AFC-Files) with CAD Software as basis for further BIMaHEAD-Modules** **Goal: Correct building constructions transferred into a precise BIM-Model** a) Learning Stage (Learning-Input) • Learn the production steps of building parts by building a VR-building part on a virtual construction site. • Learn elements functions and their subsequent mounting • Difference between reality and BIM-model: Learn which elements have to be modelled precisely, which elements can be neglected in a BIM-model. • Gain case relevant constructive knowledge b) Modelling stage (replication- and self-learning stage) • Replicate the lessons building part in an own BIM-model with your CAD-Software • Explore your CAD-Software's features, tools, and routines • Export your BIM-model as IFC-File c) Assessment Stage (Exchange stage) • Assess other students BIM-models: What could be improved? Is the model correct and precise enough? • Get tips from other students about your BIM-model • Be part of a BIM-modelling network
Learning Outcomes	a) Learn the subsequent production-steps of building parts, such as building corners, exterior walls with windows and doors, … b) Competence to transfer this knowledge into a correct 3D-Model c) Know the content of a precise 3D-BIM-model and elements to be neglected d) Acquire a BIM-Modelling logic
Learning materials (e.g. exercises, data sets)	a) Exercises in virtual rooms b) Exercises with CAD-Software c) Web based tutorials d) Assessments on Moodle-Platform

Language/s of instruction (oral and written material)	English
Method/s for teaching and learnings	a) **Gaming**: Build virtual building parts and gain constructive knowledge in a gaming environment. Learning by doing on a virtual construction site. Motivation by game-challenges. b) **Self-Learning**: use web-based tutorials and students forum within your Moodle course. c) **Competence improvement**: students' assessments on common Moodle platform. Help other students to improve their models and get experts' help and advice.
Method/s of assessment	Student-assessments: Check other students' contributions and models.
Method of course evaluation (by students, peer review etc.)	Questionnaire, Moodle anonymous feedback

Table 8.3 Clash Detection Module Syllabus

Title of the Module	**Clash Detection**
Type	online
Workload (hours)	10 hours
Institution(s)/Author	Lodz University of Technology, Poland
Prerequisites	To take this Module, students/learners should be prepared as follows: • be acquainted with basics of component structures and building materials; • be familiar with 3D modelling in BIM environment; • have the latest educational version of ArchiCAD and Solibri Model Checker installed; • optional: a VR kit suitable for use with Spatial environment.
Content/short description	The Module provides students with advanced knowledge and skills in Building Information Modelling (BIM) focused on detecting clashes and collisions in AEC projects. Collision detection software is a type of geometrical testing that improves the quality of BIM models before they

	are utilized in drawings or manufacturing. Validating model checking is carried out according to pre-set criteria and gives a yes/no response. Compliance checks include intersections of predetermined items, such as air shafts or water pipelines, with beams or walls, doublets of elements, and under-drawing mistakes. Collision detection software assists a designer in analysing construction projects by searching for potentially intersecting elements and critically analysing its results. Students will have an opportunity to acquire knowledge in a self-learning course with an innovative user interface in the form of a virtual world explored by a student-directed character.
Learning Outcomes	On successful completion of the Module, a student will gain the following practical skills: • identifying elements in the BIM model of the building; • conducting preliminary visual analysis in search for collisions; • finding collisions between elements in the building model, taking into account additional criteria and analysing them; • creating and guiding communication with the project team around errors found; • filtering elements of the building according to self-defined criteria and creating summaries; • creating a bill of materials. On successful completion of the Module, a student will gain the theoretical understanding of: • possible interdependencies between building elements; • a wider variety of realistic solutions that are feasible without the assistance of clash detection software as a designer is not an expert in each branch or may not have a lot of experience; • creating rules that are understandable to the program; • reading, analysing, and interpreting the obtained results to answer a given question.
Learning materials (e.g., exercises, data sets)	• A three-dimensional model available online in which users observe the world depicted from behind the back of a guided character (third-person perspective) and, by moving it around, discover the theory

	of clash detection in the form of a computer game. In this world, they can find various elements of the Module described in a Book of Clashes; • Moodle platform with interactive instructional videos; • IFC file containing a model of a building with several clashing elements to find; • Online presentation on the theoretical issues behind clash detection in the form of Book of Clashes; • Online tests to self-check user's knowledge and skills.
Language/s of instruction (oral and written material)	English
Method/s for teaching and learnings	A self-paced online Module includes tests, assignments, and interactive instructional videos with tasks to complete, in the spirit of gamification that engages users at the user experience level. The tasks in videos are preceded by analogous activities, but do not show the exact solution. In the case of a wrong answer, a user will get a hint, but the solution is still up to him. Only when the answer is correct will there be an opportunity to continue the episode.
Method/s of assessment	Self-assessment: a pre-test, a post-test, interactive videos with tasks. Since the Module focuses on the architectural/building part, students will work on ready-made files on which they will have to perform tasks. Working files will contain a finite number of collisions, so a check may include a numerical value corresponding to the number of elements found, their area or volume. Yes/no answers are also possible. Solving a test and answering correctly during the self-assignment will allow a learner to continue, so the Module becomes self-sufficient in terms of assessment.
Method of course evaluation (by students, peer review etc.)	Questionnaire

Table 8.4 Digital Calculation Module Syllabus

Title of the Module	**Digital Calculation**

Type	online
Workload (hours)	40 hours
Institution(s)/Author	Halmstad University, Department for Energy and Construction Engineering
Prerequisites	Students and professionals from the AEC sector
Content/short description	**Review and elaboration of the digital calculation process in construction** **Goal: Fundamental knowledge of digital calculation in its process context** a) Learning (Learning-Input) • Review of the digital construction process and its advantages • The tender and calculation process • The digital tender and calculation process b) Review of software and digitalization in practice • Review of typical software and digital processes, demos c) Assessment Stage • Assess and review finished digital calculations
Learning Outcomes	a) Knowledge about the digital construction process and its pros and cons b) Knowledge about the digital calculation process and its pros and cons c) Practical insight into digital calculation tools
Learning materials (e.g., exercises, data sets)	a) Lectures regarding the content b) Demos of digital calculation tools
Language/s of instruction (oral and written material)	English
Method/s for teaching and learnings	a) Recorded lectures: Digital reviews of the learning content b) Software demos: c) Quiz regarding lectures and demos
Method/s of assessment	Quiz
Method of course evaluation (by students, peer review etc.)	Questionnaire, Moodle anonymous feedback

Table 8.5 BIM Energy Calculation and Evaluation Module Syllabus

Title of the Module	**BIM Energy Calculation and Evaluation**
Type	online
Workload (hours)	10 hours
Institution(s)/Author	Institute for Research in Environment, Civil Engineering and Energy
Prerequisites	Students and professionals from the AEC sector
Content/short description	**Use of BIM Tools for Improvement of Energy Performance** a) Objectives of optimization of energy performance of buildings b) Design Stage • Role and importance of the design stage in energy efficiency optimization • Challenges for designers • Selection of sustainable materials and products by using BIM • Knowledge and skills in BIM and energy efficiency required for designers c) Construction stage • Role and importance of the construction stage within the building life cycle, in aspect of overall energy efficiency optimization • Use of BIM in construction stage to optimize energy performance of buildings • Knowledge and skills in BIM and energy efficiency required for site workers d) Operation Stage • Role and importance of the operation stage in energy efficiency optimization • Use of BIM in the operation stage to improve energy performance of buildings **Development of Energy Analytical Model** a) Step by step guide for development of Energy Analytical Model and Energy Analysis of a Residential Building
Learning Outcomes	a) To describe the use of BIM tools for optimization of energy performance of buildings in their complete life cycle

	b) To indicate the required knowledge and skills in BIM and energy efficiency for designers, construction site workers and building operation and maintenance managers c) To explain the roles of different users and identify the challenges in the design, construction, and operation stage d) To understand the method of creation of Energy Analytical Model based on BIM 3D model in the design stage e) To use BIM model workflow for calculation and evaluation of the energy performance of buildings
Learning materials (e.g. exercises, data sets)	Presentations, narrative videos and web-based tutorials, links for Guided self- learning. Guidelines for use of sets of tools for energy analysis of buildings, case studies
Language/s of instruction (oral and written material)	English
Method/s for teaching and learnings	Presentation of a generic workflow of development of a building, energy model, including guides for steps and checkpoints, to ensure correspondence to architectural model and basis for optimization of design alternative; replicable in other BIM software environments.
Method/s of assessment	Quizzes (assessing the level of understanding and use of BIM tools for energy efficiency evaluation)
Method of course evaluation (by students, peer review etc.)	Questionnaire, Moodle anonymous feedback

Here are the tables with all syllabuses translated into the following languages: French, German, Swedish, Macedonian, and Polish.

Syllabuses in French:

Table 8.6 BIM Form Finding from Environmental Constraints Module Syllabus in French

Titre du module	**RECHERCHE DE FORMES BIM À PARTIR DE CONTRAINTES ENVIRONNEMENTALES**
Type	En ligne

Charge de travail (heures)	20 heures (2 ECTS)
Institution(s)/Auteur	Ecole Nationale Supérieure d'Architecture de Nantes
Prérequis	Étudiants et professionnels ayant des connaissances de base sur la modélisation et les phénomènes environnementaux
Contenu/brève description	**Recherche de formes pour un meilleur projet BIM** L'intégration des phénomènes climatiques dès le début du processus de conception architecturale est cruciale pour leur bonne prise en compte. Les méthodes algorithmiques permettent d'intégrer des phénomènes climatiques complexes et dynamiques, ce qui permet d'obtenir des formes mieux adaptées aux contraintes climatiques. Ce module utilise la réalité virtuelle pour plonger les concepteurs au cœur du processus de création. a) Méthodologie • Enseignement progressif par le biais d'exercices de complexité croissante • Auto-apprentissage à son propre rythme • Possibilité de tutorat b) Objectifs • Meilleure définition des objectifs de conception • Meilleure définition du processus de conception en identifiant chaque étape • Utilisation de données climatiques de bases de données mondiales • Processus de conception qui permet à la conception générative d'ouvrir plus d'alternatives • Utilisation de la VR pour une meilleure immersion dans le processus de conception c) Enjeux • Une meilleure conception pour ralentir le changement climatique • Intégration de données multiples • Conception en fonction des contraintes environnementales • Plusieurs résultats à évaluer d) Spécificités

	• L'apprentissage de la méthodologie est plus important que l'apprentissage des logiciels • Résolution de problèmes complexes • Connexion facile au logiciel BIM **Innovation** Le cours introduit un nouveau processus de conception en suggérant une méthodologie qui comprend la collecte de données et la conception de formes complexes tout en tenant compte des contraintes climatiques. Les conceptions résultantes sont ensuite évaluées en réalité virtuelle sur une plateforme Metaverse commune, permettant une transition transparente de la conception à la communication du projet. Ce paradigme de conception innovant se concentre sur l'exploration d'une gamme de solutions qui répondent à diverses contraintes grâce à l'utilisation de méthodes de conception algorithmiques et génératives. L'intégration de la réalité virtuelle introduit de nouvelles voies pour évaluer les résultats du projet et faciliter la communication.
Résultats d'apprentissage	**Compétences** acquises • Rhino Grasshopper (conception algorithmique) • Ladybug pour les trajectoires solaires et le calcul de l'énergie (simulation climatique) • Galapagos (conception générative) • Unity (applications VR en temps réel) **Connaissances** acquises • Principes de base de la climatologie • Ambiances et confort • Outils et méthodes de conception de pointe
Matériel d'apprentissage (Par exemple, exercices, ensembles de données)	Tutoriel avec progression pas à pas. Guidage par trajets multiples pour illustrer les alternatives de conception, références externes pour enrichir le contenu, évaluation du contenu. Matériel requis : ordinateur avec puissance graphique et RAM minimum, connexion internet, casque VR optionnel.
Langue(s) d'enseignement (oral et écrit)	Anglais

Méthodes d'enseignement et d'apprentissage	Présentation d'un flux de travail générique pour le développement d'un modèle énergétique de bâtiment, comprenant des guides pour les étapes et les points de contrôle, afin d'assurer la correspondance avec le modèle architectural et la base pour l'optimisation de la conception alternative ; reproductible dans d'autres environnements logiciels BIM...
Méthode(s) d'évaluation	Quiz et flux de travail à trajets multiples qui évaluent la compréhension du processus.
Méthode d'évaluation des cours (par les étudiants, évaluation par les pairs, etc.)	Questionnaire, feedback anonyme Moodle

Table 8.7 BIM Modelling Module Syllabus in French

Titre du module	**MODÉLISATION BIM**
Type	En ligne
Charge de travail (heures)	10 heures
Institution(s)/Auteur	HafenCity University, Hamburg ; Architecture Department
Prérequis	Étudiants et professionnels du secteur AEC

Contenu/brève description	**Élaboration de modèles BIM (fichiers AFC) à l'aide d'un logiciel de CAO comme base pour d'autres modules BIMaHEAD** **Objectif : des constructions correctes transférées dans un modèle BIM précis** a) Phase d'apprentissage (entrée d'apprentissage) • Apprendre les étapes de production des pièces de construction en construisant une pièce de construction VR sur un chantier virtuel. • Apprendre les fonctions des éléments et leur montage ultérieur • Différence entre la réalité et le modèle BIM : Apprendre quels éléments doivent être modélisés avec précision et quels éléments peuvent être négligés dans un modèle BIM. • Acquérir des connaissances constructives pertinentes b) Phase de modélisation (phase de reproduction et d'auto-apprentissage) • Reproduire les leçons dans un modèle BIM avec votre logiciel de CAO • Explorer les fonctionnalités, les outils et les routines de votre logiciel de CAO • Exporter votre modèle BIM sous forme de fichier IFC c) Phase d'évaluation (phase d'échange) • Évaluer les modèles BIM d'autres étudiants : Qu'est-ce qui pourrait être amélioré ? Le modèle est-il correct et suffisamment précis ? • Obtenir des conseils d'autres étudiants sur votre modèle BIM • Faire partie d'un réseau de modélisation BIM
Résultats d'apprentissage	a) Apprendre les étapes ultérieures de la production des éléments de construction, tels que les coins de bâtiment, les murs extérieurs avec les fenêtres et les portes, ... b) Compétence pour transférer ces connaissances dans un modèle 3D correct c) Connaître le contenu d'un modèle 3D-BIM précis et les éléments à négliger d) Acquérir une logique de modélisation BIM
Matériel d'apprentissage	a) Exercices dans des salles virtuelles b) Exercices avec le logiciel CAD

(Par exemple, exercices, ensembles de données)	c) Tutoriels en ligne d) Évaluations sur la plate-forme Moodle
Langue(s) d'enseignement (oral et écrit)	Anglais
Méthodes d'enseignement et d'apprentissage	a) **Jeux** : Construire des éléments de construction virtuels et acquérir des connaissances constructives dans un environnement de jeu. Apprentissage par la pratique sur un chantier virtuel. Motivation par les défis du jeu. b) **Auto-apprentissage** : utilisez des tutoriels en ligne et un forum d'étudiants dans votre cours Moodle. c) **Amélioration des compétences** : évaluations des étudiants sur la plateforme Moodle commune. Aidez les autres étudiants à améliorer leurs modèles et obtenez l'aide et les conseils d'experts.
Méthode(s) d'évaluation	Évaluations par élèves : Vérifier les contributions et les modèles des autres élèves.
Méthode d'évaluation des cours (par les étudiants, évaluation par les pairs, etc.)	Questionnaire, feedback anonyme Moodle

Table 8.8Clash Detection Module Syllabus in French

Titre du module	**DÉTECTION DES COLLISIONS**
Type	En ligne
Charge de travail (heures)	10 heures
Institution(s)/Auteur	Lodz University of Technology, Poland
Prérequis	Pour suivre ce module, les étudiants/apprenants doivent être préparés comme suit : • Être familiarisé avec les bases des structures des composants et des matériaux de construction ; • Être familiarisé avec la modélisation 3D dans un environnement BIM ;

	• Avoir installé la dernière version éducative d'ArchiCAD et de Solibri Model Checker ; • En option : un kit VR adapté à l'utilisation de l'environnement Spatial.
Contenu/brève description	Ce module permet aux étudiants d'acquérir des connaissances et des compétences avancées en matière de modélisation de l'information sur les bâtiments (BIM), axées sur la détection des heurts et des collisions dans les projets d'architecture et de construction. Le logiciel de détection des collisions est un type de test géométrique qui améliore la qualité des modèles BIM avant qu'ils ne soient utilisés dans les dessins ou la fabrication. Le contrôle des modèles de validation est effectué selon des critères prédéfinis et donne une réponse oui/non. Les contrôles de conformité comprennent les intersections d'éléments prédéterminés, tels que les puits d'aération ou les conduites d'eau, avec des poutres ou des murs, les doublets d'éléments et les erreurs de sous-dessin. Le logiciel de détection des collisions aide le concepteur à analyser les projets de construction en recherchant les éléments susceptibles de se croiser et en analysant les résultats de manière critique.
Résultats d'apprentissage	A l'issue de ce module, l'étudiant aura acquis les compétences pratiques suivantes : • Identifier les éléments dans le modèle BIM du bâtiment ; • Effectuer une analyse visuelle préliminaire à la recherche de collisions ; • Rechercher des collisions entre les éléments du modèle de bâtiment, en tenant compte de critères supplémentaires et en les analysant ; • Créer et guider la communication avec l'équipe de projet sur les erreurs détectées ; • Filtrer les éléments du bâtiment selon des critères définis par l'utilisateur et créer des résumés ; • Création d'une nomenclature. A l'issue de ce module, l'étudiant aura acquis une compréhension théorique des éléments suivants : • Les interdépendances possibles entre les éléments du bâtiment ;

	• Une plus grande variété de solutions réalistes qui sont réalisables sans l'aide d'un logiciel de détection des collisions, car le concepteur n'est pas un expert dans chaque branche ou n'a pas beaucoup d'expérience ; • Créer des règles compréhensibles pour le programme ; • Lire, analyser et interpréter les résultats obtenus pour répondre à une question donnée.
Matériel d'apprentissage (Par exemple, exercices, ensembles de données)	• Modèle tridimensionnel disponible en ligne dans lequel l'utilisateur observe le monde représenté dans le dos d'un personnage guidé (perspective à la troisième personne) et, en le déplaçant, découvre la théorie de la détection des collisions sous la forme d'un jeu informatique. Dans ce monde, ils peuvent trouver divers éléments du module décrit dans un livre des affrontements ; • Plateforme Moodle avec des vidéos pédagogiques interactives ; • Fichier IFC contenant un modèle de bâtiment avec un certain nombre d'éléments en conflit à trouver ; • Présentation en ligne des aspects théoriques de la détection des collisions sous la forme d'un livre des collisions ; • Tests en ligne pour vérifier les connaissances et les compétences de l'utilisateur.
Langue(s) d'enseignement (oral et écrit)	Anglais
Méthodes d'enseignement et d'apprentissage	Un module en ligne autodidacte comprend des tests, des devoirs et des vidéos pédagogiques interactives avec des tâches à accomplir, dans l'esprit de la gamification qui engage les utilisateurs au niveau de l'expérience de l'utilisateur. Les tâches dans les vidéos sont précédées d'activités analogues, mais ne montrent pas la solution exacte. En cas de mauvaise réponse, l'utilisateur reçoit un indice, mais la solution lui appartient toujours. Ce n'est que lorsque la réponse est correcte qu'il a la possibilité de poursuivre l'épisode.
Méthode(s) d'évaluation	Auto-évaluation : un pré-test, un post-test, des vidéos interactives avec des tâches.

	Étant donné que le module se concentre sur la partie architecture/bâtiment, les étudiants travailleront sur des fichiers prêts à l'emploi sur lesquels ils devront effectuer des tâches. Les fichiers de travail contiendront un nombre fini de collisions, de sorte qu'un contrôle peut inclure une valeur numérique correspondant au nombre d'éléments trouvés, à leur surface ou à leur volume. Des réponses de type oui/non sont également possibles. La résolution d'un test et une réponse correcte lors de l'auto-évaluation permettront à l'apprenant de poursuivre, le module devenant ainsi autonome en termes d'évaluation.
Méthode d'évaluation des cours (par les étudiants, évaluation par les pairs, etc.)	Questionnaire

Table 8.9 Digital Calculation Module Syllabus in French

Titre du module	**CALCUL NUMÉRIQUE**
Type	En ligne
Charge de travail (heures)	40 heures
Institution(s)/Auteur	Halmstad University, Department for Energy and Construction Engineering
Prérequis	Étudiants et professionnels du secteur AEC

Contenu/brève description	**Révision et élaboration du processus de calcul numérique dans la construction** **Objectif : Connaissance fondamentale du calcul numérique dans son contexte de processus** a) Apprentissage (entrée d'apprentissage) • Examen du processus de construction numérique et de ses avantages • La procédure d'appel d'offres et de calcul • L'appel d'offres numérique et le processus de calcul b) Examen des logiciels et de la numérisation dans la pratique • Examen des logiciels typiques et des processus numériques, démonstrations c) Phase d'évaluation • Évaluer et réviser les calculs numériques terminés
Résultats d'apprentissage	a) Connaissance du processus de construction numérique et de ses avantages et inconvénients b) Connaissance du processus de calcul numérique et de ses avantages et inconvénients c) Aperçu pratique des outils de calcul numérique
Matériel d'apprentissage (Par exemple, exercices, ensembles de données)	a) Conférences sur le contenu b) Démonstrations d'outils de calcul numérique
Langue(s) d'enseignement (oral et écrit)	Anglais
Méthodes d'enseignement et d'apprentissage	a) Conférences enregistrées : Examens numériques du contenu de l'apprentissage b) Démonstrations de logiciels c) Quiz concernant les conférences et les démonstrations
Méthode(s) d'évaluation	Quiz
Méthode d'évaluation des cours (par les étudiants, évaluation par les pairs, etc.)	Questionnaire, feedback anonyme Moodle

Table 8.10 BIM Energy Calculation and Evaluation Module Syllabus in French

Titre du module	**CALCUL ET ÉVALUATION DE L'ÉNERGIE PAR LE BIM**
Type	En ligne
Charge de travail (heures)	10 heures
Institution(s)/Auteur	Institute for Research in Environment, Civil Engineering and Energy
Prérequis	Étudiants et professionnels du secteur AEC
Contenu/brève description	**Utilisation des outils BIM pour l'amélioration de la performance énergétique** a) Objectifs de l'optimisation de la performance énergétique des bâtiments b) Phase de conception • Rôle et importance de la phase de conception dans l'optimisation de l'efficacité énergétique • Défis pour les concepteurs • Sélection de matériaux et de produits durables à l'aide de la BIM • Connaissances et compétences en matière de BIM et d'efficacité énergétique requises pour les concepteurs c) Phase de construction • Rôle et importance de la phase de construction dans le cycle de vie du bâtiment, dans l'optique d'une optimisation globale de l'efficacité énergétique • Utilisation du BIM au stade de la construction pour optimiser la performance énergétique des bâtiments • Connaissances et compétences en matière de BIM et d'efficacité énergétique requises pour les travailleurs de chantier d) Étape de réalisation • Rôle et importance de la phase d'exploitation dans l'optimisation de l'efficacité énergétique • Utilisation du BIM au stade de l'exploitation pour améliorer la performance énergétique des bâtiments **Développement d'un modèle analytique de l'énergie**

	Guide étape par étape pour l'élaboration d'un Modèle analytique énergétique et analyse énergétique d'un bâtiment résidentiel
Résultats d'apprentissage	a) Décrire l'utilisation des outils BIM pour l'optimisation de la performance énergétique des bâtiments tout au long de leur cycle de vie. b) Indiquer les connaissances et les compétences requises en matière de BIM et d'efficacité énergétique pour les concepteurs, les ouvriers de chantier et les responsables de l'exploitation et de la maintenance des bâtiments. c) Expliquer les rôles des différents utilisateurs et identifier les défis à relever aux stades de la conception, de la construction et de l'exploitation. d) Comprendre la méthode de création d'un modèle analytique énergétique basé sur le modèle BIM 3D au stade de la conception. e) Utiliser le flux de travail du modèle BIM pour le calcul et l'évaluation de la performance énergétique des bâtiments.
Matériel d'apprentissage (Par exemple, exercices, ensembles de données)	Présentations, vidéos narratives et tutoriels en ligne, liens pour l'auto-apprentissage guidé. Lignes directrices pour l'utilisation d'ensembles d'outils pour l'analyse énergétique des bâtiments, études de cas.
Langue(s) d'enseignement (oral et écrit)	Anglais
Méthodes d'enseignement et d'apprentissage	Présentation d'un flux de travail générique pour le développement d'un modèle énergétique du bâtiment, comprenant des guides pour les étapes et les points de contrôle, afin d'assurer la correspondance avec le modèle architectural et la base pour l'optimisation de la conception alternative ; reproductible dans d'autres environnements logiciels BIM...
Méthode(s) d'évaluation	Quiz (évaluation du niveau de compréhension et d'utilisation des outils BIM pour l'évaluation de l'efficacité énergétique.
Méthode d'évaluation des cours (par les étudiants, évaluation par les pairs, etc.)	Questionnaire, feedback anonyme Moodle

Syllabuses in German:

Table 8.11 BIM Form Finding from Environmental Constraints Module Syllabus in German

Table 8.12 BIM Modelling Module Syllabus in German

Modul	**BIM Modeling**
Typ	online
Arbeitsumfang (Stunden)	Für jede Übung (working package): Virtuelle Baustelle: 0,5 Stunde, Modellierung & Selbstlernphase: 1 Stunde, Bewertung: 0,5 Stunde, Mehr als 10 Stunden Arbeitsaufwand für das eigentliche Modul mit 5 Übungen
Institution / Autor	HafenCity Universität, Hamburg; Studiengang Architektur - Baukonstruktion
Voraussetzungen	Grundlegende baukonstruktive Kenntnisse

Inhalt/ Kurzbeschreibung	**Erarbeitung von BIM-Modellen (AFC-Dateien) mit CAD-Software als Basis für weitere BIMaHEAD-Module** **Ziel: Korrekte Baukonstruktionen in ein präzises BIM-Modell zu überführen** a) **Lernphase (Lern-Input)** • Erlernen der Fertigungsschritte von Bauteilen durch den Bau eines VR-Bauteils auf einer virtuellen Baustelle. • Erlernen der Elementfunktionen und deren aufeinander folgende Montage • Unterschied zwischen Realität und BIM-Modell: Lernen, welche Elemente genau modelliert werden müssen, welche Elemente in einem BIM-Modell vernachlässigt werden können. • Gewinnung von fallbezogenem konstruktivem Wissen b) **Modellierungsphase (Replikations- und Selbstlernphase)** • Reproduzieren Sie das VR-Gebäudeteil in einem eigenen BIM-Modell mit Ihrer CAD-Software • Erkunden Sie die Funktionen, Werkzeuge und Routinen Ihrer CAD-Software • Exportieren Sie Ihr BIM-Modell als IFC-Datei c) **Bewertungsphase (Austauschphase)** • Beurteilen Sie die BIM-Modelle anderer Studenten: Was könnte verbessert werden? Ist das Modell korrekt und präzise genug? • Holen Sie sich Tipps von anderen Studenten zu Ihrem BIM-Modell • Werden Sie Teil eines BIM-Modellierungsnetzwerks
Lernziele	a) Erlernen der sukzessiven Fertigungsschritte von Gebäudeteilen, wie Gebäudeecken, Außenwände mit Fenstern und Türen, ... b) Kompetenzerwerb, dieses Wissen in einem korrekten 3D-Modell abzubilden c) Kenntnis der Inhalte eines genauen 3D-BIM-Modells und der zu vernachlässigenden Elemente d) Aneignung einer BIM-Modellierungs-Logik
Lernmaterial und -umgebung	a) Interaktive Übungen in virtuellen Räumen b) CAD - Übungen

	c) Webbasierte Tutorien d) Prüfungen auf der Moodle-Plattform
Unterrichtsprache	Englisch
Lehr- und Lernmethoden	a) **Gaming**: Bauen Sie virtuelle Gebäudeteile und erwerben Sie konstruktives Wissen in einer Spieleumgebung. Learning by doing auf einer virtuellen Baustelle. Motivation durch Challenges. b) **Selbstlernphase**: Nutzen Sie webbasierte Tutorials und ein Studentenforum in Ihrem Moodle-Kurs. c) **Kompetenzerwerb**: Bewertungen der Studenten auf der gemeinsamen Moodle-Plattform. Helfen Sie anderen Studierenden, ihre Modelle zu verbessern und holen Sie sich Hilfe und Ratschläge von Experten.
Bewertungsmethode(n)	Gegenseitige Bewertungen: Überprüfen Sie die Beiträge und Modelle anderer Teilnehmer. Vergleichen Sie mit Ihren Beiträgen.
Kurs-Evaluation	Fragebogen, anonymes Moodle-Feedback

Table 8.13 Clash Detection Module Syllabus in German

Table 8.14 Digital Calculation Module Syllabus in German

Table 8.15 BIM Energy Calculation and Evaluation Module Syllabus in German

Syllabuses in Swedish:

Table 8.16 BIM Form Finding from Environmental Constraints Module Syllabus in Swedish

Modulnamn	**BIM Gestaltning med klimathänsyn**
Undervisningssätt	online
Arbetsinsats (timmar)	20 timmar
Institution	Ecole Nationale Supérieure d'Architecture de Nantes

Förkunskapskrav	Studenter och yrkesverksamma med grundläggande kunskaper om modellering och klimatrelaterade fenomen
Innehåll/kort beskrivning	**Gestaltning för bättre BIM-projekt** Att integrera klimatfenomen tidigt i den arkitektoniska designprocessen är avgörande för att de ska beaktas på rätt sätt. Algoritmiska metoder gör det möjligt att integrera komplexa och dynamiska klimatfenomen, vilket resulterar i former som är bättre lämpade för klimathänsyn. I den här modulen används en virtuell verklighet för att ge arkitekter en verklighetsnära inblick i skapandeprocessen. a) Metodik • Progressiv undervisning genom övningar med ökande komplexitet • Självstudier i egen takt • Möjlighet till handledning b) Mål • Bättre förståelse för designmål • Bättre förståelse för designprocessen genom identifiering av varje nödvändigt steg • Tillämpning av klimatdata • Designprocess som möjliggör generativ design för att öppna upp för fler alternativa lösningar • Användning av VR för en bättre verklighetsförankring I designprocessen c) Frågeställningar • Bättre design för att bromsa klimatförändringarna • Integration av många designmål • Utformning med miljömässiga begränsningar • Utvärdering av alternativa resultat d) Särskilda egenskaper • Metodfokus snarare än mjukvaruhantering • Komplex problemlösning • Lätt att kombinera med BIM-programvara **Innovation**

	Kursen introducerar en ny designprocess genom att föreslå en metod som inkluderar datainsamling och design av komplicerade former samtidigt som man tar klimathänsyn. Resultatet utvärderas sedan I en virtuell verklighet på en gemensam Metaverse-plattform, vilket möjliggör en sömlös övergång från design till projektkommunikation. Detta innovativa designparadigm fokuserar på att utforska en rad olika lösningar som uppfyller olika begränsningar genom användning av algoritmiska och generativa designmetoder. Integreringen av virtuell verklighet skapar nya möjligheter att utvärdera projektresultat och underlätta kommunikationen.
Lärandemål	**Färdigheter** • Rhino Grasshopper (algoritmisk design) • Ladybug för solkurvor och energiberäkning (klimatsimulering) • Galapagos (generativ design) • Unity (VR-tillämpningar i realtid) **Kunskaper** • Grundläggande klimatologiska principer • Miljöer och komfort • Toppmoderna designverktyg och metoder
Undervisningsmaterial	Vägledning med stegvis progression. Flervägsstyrning för att illustrera designalternativ, omvärldsreferenser för att berika innehållet, innehållsutvärdering. Hårdvarukrav: dator med minsta möjliga grafik och RAM-minne, internetanslutning, VR-headset (tillval).
Undervisningsspråk	Engelska
Undervisningsformer	Presentera en allmän arbetsprocess för att utveckla en byggnads- och energimodell, vilket inkluderar stegvisa guider och kontrollpunkter för att säkerställa att den arkitektoniska modellen följer och fungerar som grund för att optimera designalternativ. Denna process kan replikeras i andra BIM-programvarumiljöer.
Examinationsformer	Duggor och flervägsarbetsflöden används för att utvärdera förståelsen av processen.

Former för kursutvärdering	Frågeformulär, anonym feedback från Moodle.

Table 8.17 BIM Modelling Module Syllabus in Swedish

Modulnamn	**BIM Modellering**
Undervisningssätt	online
Arbetsinsats (timmar)	10 timmar
Institution	HafenCity University, Hamburg; Architecture Department
Förkunskapskrav	Studenter och yrkesverksamma inom bygg- och projekteringsindustrin
Innehåll/kort beskrivning	**Utarbetande av BIM-modeller (IFC-filer) med CAD-programvara som grund** **Mål: Korrekta byggnadskonstruktioner överförda till exakta BIM-modeller** a) Inlärningssteg • produktionsstegen för byggnadsdelar genom att bygga en VR-byggnadsdel på en virtuell byggarbetsplats. • Byggelementens funktioner och deras efterföljande montering. • Skillnaden mellan verklighet och BIM-modell: Lär dig vilka element som måste modelleras noggrant, och vilka element som kan försummas i en BIM-modell. • Relevant och praktisk konstruktionskunskap b) Modellering (replikerings- och självinlärningsstadiet) • replikera lektionens byggnadsdel i en egen BIM-modell med din CAD-programvara. • Utforska CAD-programmets funktioner, verktyg och rutiner. • Exporter BIM-modeller som IFC-filer c) Bedömning (erfarenhetsutbyte) • Utvärdera andra studenters BIM-modeller: Vad kan förbättras? Är modellen tillräckligt korrekt och exakt? • Få tips från andra studenter om din BIM-modell • Var en del av ett nätverk för BIM-modellering

Lärandemål	a) Lära sig produktionsstegen för byggnadsdelar, t.ex. byggnadshörn, ytterväggar med fönster och dörrar ... b) Kompetens att överföra denna kunskap till en korrekt 3D-modell c) Känna till innehållet i en exakt 3D-BIM-modell och vilka element som kan försummas d) Lära sig en BIM-modelleringslogik
Undervisningsmaterial	a) Övningar i virtuella klassrum b) Övningar med CAD-mjukvara c) Webbaserade handledningar d) Bedömingsövningar på Moodle
Undervisningsspråk	Engelska
Undervisningsformer	a) **Gaming**: Bygg virtuella byggdelar och få konstruktiv kunskap I en spelmiljö. Lär dig genom att göra på en virtuell byggarbetsplats. Motivation genom spelutmaningar. b) **Självinlärning**: använd webbaserade handledningar och studentforum i din Moodle-kurs. c) **Kompetensutveckling**: studenternas utvärderingar på en gemensam Moodle-plattform. Hjälp andra studenter att förbättra sina modeller och få hjälp och råd från experter.
Examinationsformer	Kamratgranskning: Bedöm andra studenters bidrag och modeller.
Former för kursutvärdering	Frågeformulär, anonym feedback från Moodle.

Table 8.18 Clash Detection Module Syllabus in Swedish

Modulnamn	**Kollisionsdetektering**
Undervisningssätt	online
Arbetsinsats (timmar)	10 timmar
Institution	Lodz University of Technology, Poland
Förkunskapskrav	För att ta denna modul bör studenterna/eleverna vara förberedda enligt följande: • vara bekant med grunderna för komponentstrukturer och byggmaterial;

	• vara bekant med 3D-modellering i BIM-miljö; • ha den senaste utbildningsversionen av ArchiCAD och Solibri Model Checker installerad; • valfritt: ett VR-kit som är lämpligt för användning med Spatial-miljö.
Innehåll/kort beskrivning	Modulen ger studenterna avancerad kunskap och färdigheter inom Building Information Modelling (BIM) med fokus på att upptäcka kollisioner och sammanstötningar i byggprojekt. Kollisionsdetektionsprogramvara är en typ av geometrisk testning som förbättrar kvaliteten på BIM-modeller innan de används i ritningar eller tillverkning. Validering av modellkontroll utförs enligt förinställda kriterier och ger ett ja/nej-svar. Överensstämmelsekontroller inkluderar korsningar av fördefinierade objekt, såsom luftkanaler eller vattenledningar, med balkar eller väggar, dubbletter av element och fel I underlaget. Kollisionsdetektionsprogramvara underlättar för en designer att analysera byggprojekt genom att söka efter potentiellt korsande element och kritiskt analysera resultaten. Studenterna kommer att få möjlighet att skaffa sig kunskap I en självlärande kurs med en innovativ användargränssnitt i form av en virtuell värld som utforskas av en studentstyrd karaktär.
Lärandemål	Efter att ha genomfört modulen kommer en student att få följande praktiska färdigheter: • Identifiera elementen i byggnadens BIM-modell. • Utföra preliminär visuell analys för att hitta kollisioner. • Hitta kollisioner mellan element i byggnadsmodellen, med beaktande av ytterligare kriterier och analysera dem. • Skapa och leda kommunikation med projektteamet angående upptäckta fel. • Filtrera byggnadens element enligt egendefinierade kriterier och skapa sammanfattningar. • Skapa en materiallista (strecklista). Efter att ha genomfört modulen kommer en student att få teoretisk förståelse för: • Möjliga samband mellan byggnadselement.

	• En variation av realistiska lösningar som är genomförbara utan hjälp av krockdetektionsprogramvara, eftersom en designer inte är expert inom varje område eller kanske saknar specifik erfarenhet. • Skapa regler som är begripliga för programvaran. • Läsa, analysera och tolka de erhållna resultaten för att svara på en given fråga.
Undervisningsmaterial	• En tredimensionell modell tillgänglig online i vilken användarna observerar den avbildade världen bakom ryggen på en styrd figur (tredjepersonsperspektiv) och, genom att flytta runt den, upptäcker teorin om konfliktdetektering i form av ett datorspel. I denna värld kan de hitta olika delar av den modul som beskrivs i en i "Book of Clashes”. • Moodle-plattform med interaktiva instruktionsvideor. • IFC-fil som innehåller en modell av en byggnad med ett antal kolliderande element att hitta. • Online-presentation om de teoretiska ämnena bakom krockdetektering i form av "Book of Clashes”. • Online-test för att självutvärdering av användarens kunskaper och färdigheter.
Undervisningsspråk	Engelska
Undervisningsformer	En online-modul i egen takt som inkluderar tester, uppgifter och interaktiva instruktionsvideor med uppgifter att slutföra, i enlighet med gamification-konceptet som engagerar användarna på användarupplevelsenivån. Uppgifterna i videorna föregås av motsvarande aktiviteter, men som inte visar den exakta lösningen. Om användaren ger fel svar får hen en ledtråd, men lösningen ligger fortfarande hos användaren. Endast när svaret är korrekt kommer det att finnas möjlighet att fortsätta avsnittet.
Examinationsformer	Självbedömning: ett förtest, ett eftertest, interaktiva videor med uppgifter. Eftersom modulen är inriktad på arkitektur/byggnadsdelar kommer studenterna att arbeta med färdiga filer som de måste utföra uppgifter

	på. Arbetsfilerna kommer att innehålla ett begränsat antal kollisioner, så en kontroll kan innehålla ett numeriskt värde som motsvarar antalet element som hittats, deras area eller volym. Ja/nej-svar är också möjliga. Att lösa ett test och svara rätt under självuppgiften gör att en student kan fortsätta, så att modulen blir självgående när det gäller bedömning.
Former för kursutvärdering	Frågeformulär, anonym feedback från Moodle.

Table 8.19 Digital Calculation Module Syllabus in Swedish

Modulnamn	**Digital kalkylering**
Undervisningssätt	Online
Arbetsinsats (timmar)	40 timmar (1,5 ECTS)
Institution	Högskolan I Halmstad, Avdelningen för bygg och energiteknik,
Förkunskapskrav	Studenter och verksamma från byggsektorn
Innehåll/kort beskrivning	**Överblick och översyn av den digitala kalkyleringsprocessen för byggprocessen** **Mål: Grundläggande kunskap om digital kalkylering i en byggkontext** a) Lärande, översyn • Genomgång av den digitala byggprocessen och dess fördelar • Anbuds och kalkyleringsprocessen • Den digitala anbuds och kalkyleringsprocessen b) Överblick av mjukvara och digitalisering I praktiken • Översyn av typisk mjukvara och digitala processer, demos c) Bedömning av gjorda kalkyleringar • Bedömning och översyn av färdiga kalkyleringar
Lärandemål	a) Kunskap om den digitala byggprocessen och dess för- och nackdelar b) Kunskap om den digitala kalkyleringsprocessen och dess för- och nackdelar c) Praktisk insyn I digitala kalkyleringsverktyg
Undervisningsmaterial	a) Inspelade föreläsningar om innehållet (se ovan) b) Demos av digitala kalkyleringsverktyg

Undervisningsspråk	Engelska
Undervisningsformer	a) Inspelade föreläsningar av lärandeinnehållet b) Demos av mjukvaror c) Undervisande frågor rörande föreläsningar och demos
Examinationsformer	Undervisande Quiz
Former för kursutvärdering	Frågeformulär, Moodle anonym feedback

Table 8.20 BIM Energy Calculation and Evaluation Module Syllabus in Swedish

Modulnamn	**BIM Energiberäkning och Utvärdering**
Undervisningssätt	Online
Arbetsinsats (timmar)	10 timmar
Institution	Institute for Research in Environment, Civil Engineering and Energy
Förkunskapskrav	Studenter och yrkesverksamma från AEC sector
Innehåll/kort beskrivning	**Användande av BIM verktyg för förbättring av Energiprestanda** a) Mål med optimering av energiprestanda hos byggnader b) Konstruktionsstadie • Roll och signifikans av konstruktionsstadiet rörande optimering av energiprestanda • Utmaningar för konstruktörer • Val av hållbara material och produkter genom att använda BIM • Kunskaper och färdigheter rörande BIM och energieffektivitet för konstruktörer c) Utförandestadie • Roll och signifikans för utförandestadiet av byggnadens livscykel med avseende på övergripande energiprestanda-optimering • Användande av BIM i utförandestadiet för att optimera energiprestanda hos byggnader • Kunskaper och färdigheter rörande BIM och energieffektivitet på produktionsplatsen d) Förvaltning stadie

	• Roll och signifikans för förvaltningsstadiet rörande energiprestandaoptimering • Användande av BIM I förvaltningsskedet för att förbättra energiprestanda hos byggnader **Utveckling av modell för Energianalys** a) Stegvis guide för utveckling av modell för energianalys
Lärandemål	a) Att beskriva användandet av BIM-verktyg I byggnaders hela livscykel för optimering av energiprestanda b) Belysa nödvändiga kunskaper och färdigheter inom BIM och energieffektivitet för konstruktörer, produktionsplats och förvaltning. c) Förklara olika användares roller och identifiera design-utmaningar I konstruktion, utförande och förvaltning d) Förstå metoden för att skapa en modell för energianalys baserat på en BIM 3D-modell i konstruktions-stadiet e) Att använda en BIM-modells arbetsflöde för att kalkylering och utvärdering av energiprestanda hos byggnader
Undervisningsmaterial	Presentationer, instruerande videos och web-baserad handledning, Länkar till guidad självlärning, riktlinjer för användande av verktyg för energianalys av byggnader, Fallstudie
Undervisningsspråk	Engelska
Undervisningsformer	Presentation av ett generiskt arbetsflöde för utveckling av en modell av energi med steg och hållpunkter, för att försäkra sig om att denna korrelerar med arkitektonisk modell och ger en bas för konstruktionsalternativ. Replikerbar i andra mjukvarumiljöer relaterat till BIM.
Examinationsformer	Quiz (bedömer nivån på förståelse och användandet av BIM verktyg för utvärdering av energiprestanda)
Former för kursutvärdering	Frågeformulär, Moodle anonym feedback

Syllabuses in Macedonian:

Table 8.21 BIM Form Finding from Environmental Constraints Module Syllabus in Macedonian

Table 8.22 BIM Modelling Module Syllabus in Macedonian

Table 8.23 Clash Detection Module Syllabus in Macedonian

Table 8.24 Digital Calculation Module Syllabus in Macedonian

Table 8.25 BIM Energy Calculation and Evaluation Module Syllabus in Macedonian

Syllabuses in Polish:

Table 8.26 BIM Form Finding from Environmental Constraints Module Syllabus in Polish

Nazwa Modułu	**Poszukiwanie formy w BIM na podstawie ograniczeń środowiskowych**
Typ	online
Liczba godzin	20 godzin
Instytucja / Autorstwo Modułu	Ecole Nationale Supérieure d'Architecture de Nantes
Wymagania wstępne	Studenci i specjaliści posiadający podstawową wiedzę z zakresu modelowania i zjawisk środowiskowych.
Opis treści Modułu	Celem przedmiotu jest włączenie zjawisk klimatycznych na wczesnym etapie procesu projektowania architektonicznego przy pomocy metod algorytmicznych. Moduł ten wykorzystuje rzeczywistość wirtualną, aby zrozumieć lepiej procesy tworzenia projektu. a) Metodyka • Samodzielne realizowanie tutoriali o zwiększającym się poziomie trudności • Samokształcenie we własnym tempie • Możliwość prowadzenia zajęć dydaktycznych b) Cele • Definiowanie celów projektowych oraz procesu projektowania poprzez identyfikację poszczególnych kroków. • Wykorzystanie danych klimatycznych z dostępnych baz danych. • Automatyzacja procesu projektowania generatywnego.

	• Wykorzystanie VR do lepszego zrozumienia procesu projektowania c) Zagadnienia • Projektowanie według ograniczeń środowiskowych w celu spowolnienia zmian klimatycznych. • Integracja wielu danych wejściowych oraz porównanie wyników wyjściowych. Złożone rozwiązywanie problemów. • Uczenie się metodologii projektowania. • Łatwe połączenie z oprogramowaniem BIM.
Efekty uczenia się	a) Student zna i rozumie problematykę podstawowych zasady klimatologii oraz potrafi zastosować ją w procesie projektowania. Rozumie metodologie projektowania generatywnego oraz algorytmicznego. b) Potrafi używać takie narzędzia jak Rhinoceros, Grasshoper, Ladybug (symulacje klimatyczne), Galapagos (projektowanie generatywne), Unity (VR w czasie rzeczywistym).
Materiały dydaktyczne	a) Samouczki internetowe b) Wymagania sprzętowe: komputer z minimalną mocą graficzną i RAM, połączenie z Internetem, opcjonalnie zestaw
Język	angielski
Metody dydaktyczne	Samokształcenie: Prezentacje oraz tutoriale.
Metody weryfikacji efektów uczenia się	Quizy i wielotorowa ścieżka pracy, która ocenia zrozumienie procesu.
Metody ewaluacji Modułu	Kwestionariusz, anonimowa informacja zwrotna Moodle

Table 8.27 BIM Modelling Module Syllabus in Polish

Nazwa Modułu	**Modelowanie BIM**
Typ	online
Liczba godzin	10 godzin
Instytucja / Autorstwo Modułu	Uniwersytet HafenCity, Hamburg; Wydział Architektury
Wymagania wstępne	Studenci i specjaliści z branży AEC

Opis treści Modułu	**Celem przedmiotu jest zapoznanie studenta z opracowaniem modeli BIM (plików AFC) za pomocą oprogramowania CAD jako podstawą do dalszych modułów BIMaHEAD.** c) Etap nauki (Learning-Input): • Nauka etapów produkcji części budowlanych na wirtualnym placu budowy. • Poznawanie funkcji elementów i ich późniejszego montażu. • Poznanie różnicy między rzeczywistością a BIM-modelem: elementy konieczne do zamodelowania oraz pomijalne. d) Etap modelowania (etap replikacji i samokształcenia) • Nauka danego oprogramowania CAD jako narzędzia do modelowania BIM. • Zastosowanie zdobytej wiedzy we własnym modelu z użyciem oprogramowania CAD. • Eksportowanie modelu BIM do formatu IFC. e) Etap oceny (etap wymiany) • Ocena modeli BIM innych uczestników. • Tworzenie społeczności wirtualnej BIM.
Efekty uczenia się	W zakresie znajomości teorii, po pomyślnym ukończeniu Modułu, student: a) Zna i rozumie problematykę kolejnych etapów produkcji elementów budynku, takich jak narożniki budynków, ściany zewnętrzne z oknami i drzwiami. b) Zna i rozumie zawartość precyzyjnego modelu 3D BIM. c) Zna i rozumie logikę modelowania BIM. W zakresie umiejętności praktycznych, po pomyślnym ukończeniu modułu student: a) Potrafi przenieść wiedzę na poprawny model 3D.
Materiały dydaktyczne	a) Ćwiczenia w wirtualnym modelu VR b) Ćwiczenia z oprogramowaniem CAD c) Samouczki internetowe d) Ocenianie na platformie Moodle
Język	angielski

Metody dydaktyczne	a) **Gaming**: Budowanie wirtualnych elementów budynku i zdobywanie wiedzy w środowisku gry. Nauka przez działanie na wirtualnym placu budowy. b) **Samokształcenie**: zastosowanie tutoriali oraz forum uczestników na platformie kursu. c) **Podnoszenie kompetencji**: oceny studentów na wspólnej platformie kursu. Wzajemna pomoc studentów w poprawie ich modeli oraz wsparcie ekspertów.
Metody weryfikacji efektów uczenia się	Oceny kursantów: Wzajemna ocena prac przez uczestników.
Metody ewaluacji Modułu	Kwestionariusz, anonimowa informacja zwrotna Moodle

Table 8.28 Clash Detection Module Syllabus in Polish

Nazwa Modułu	**Wykrywanie kolizji w BIM (Clash Detection)**
Typ	online
Liczba godzin	10 godzin
Instytucja / Autorstwo Modułu	Politechnika Łódzka
Wymagania wstępne	Aby przystąpić do realizacji tego Modułu, studenci/kursanci powinni być przygotowani w następujący sposób: • być zaznajomieni z podstawami konstrukcji elementów i materiałów budowlanych; • być zaznajomiony z modelowaniem 3D w środowisku BIM; • posiadać zainstalowaną najnowszą edukacyjną wersję programu ArchiCAD oraz Solibri Model Checker; • opcjonalnie: posiadać zestaw VR (wirtualnej rzeczywistości) przystosowany do pracy ze środowiskiem Spatial.
Opis treści Modułu	Moduł zapewnia studentom zaawansowaną wiedzę i umiejętności w zakresie modelowania informacji o budynku (BIM) z zakresu wykrywania kolizji (clash detection) w projektach AEC. Oprogramowanie do wykrywania kolizji jest rodzajem testów geometrycznych, które poprawiają jakość

	modeli BIM zanim zostaną one wykorzystane w rysunkach lub produkcji. Sprawdzanie zgodności modelu odbywa się według wcześniej ustalonych kryteriów i daje odpowiedź o ich spełnieniu bądź nie. Kontrole zgodności obejmują przecinanie się wcześniej określonych elementów, takich jak: szyby wentylacyjne lub rurociągi z belkami konstrukcyjnymi lub ścianami, dublowanie elementów oraz błędy w rysunkach. Oprogramowanie do wykrywania kolizji wspomaga projektanta w analizie projektów budowlanych poprzez wyszukiwanie potencjalnie przecinających się elementów i krytyczną analizę jej wyników. Uczestnicy kursy będą mieli możliwość zdobycia wiedzy w kursie przeznaczonym do samodzielnej nauki z innowacyjnym interfejsem użytkownika w postaci wirtualnego świata eksplorowanego za pośrednictwem kierowanej przez studenta postaci.
Efekty uczenia się	Po pomyślnym ukończeniu modułu student zdobędzie następujące umiejętności praktyczne: • identyfikowanie elementów w modelu BIM budynku; • przeprowadzanie wstępnej analizy wizualnej w poszukiwaniu kolizji; • znajdowanie kolizji pomiędzy elementami w modelu budynku, uwzględnianie dodatkowych kryteriów i ich analiza; • tworzenie i prowadzenie komunikacji z zespołem projektowym dotyczącej znalezionych błędów; • filtrowanie elementów budynku według samodzielnie zdefiniowanych kryteriów i tworzenie odpowiednich zestawień; • tworzenie zestawień materiałów. Po pomyślnym ukończeniu Modułu, student zdobędzie teoretyczne rozeznanie w zakresie: • możliwych współzależności pomiędzy elementami budynku; • szerszej gamy rozwiązań, które są możliwe do zastosowania co byłoby trudne bez pomocy oprogramowania do wykrywania kolizji, jako że projektant nie jest ekspertem w każdej branży lub może nie mieć dużego doświadczenia; • tworzenia reguł, które są zrozumiałe dla programu;

	• odczytywania, analizowania i interpretowania uzyskanych wyników w celu odpowiedzi na zadane pytanie.
Materiały dydaktyczne	• Trójwymiarowy model budynku z otoczeniem dostępny online, w którym użytkownicy obserwują świat przedstawiony zza pleców prowadzonej postaci (perspektywa trzecioosobowa) i poruszając się nią jak w grze komputerowej, poznają teorię z zakresu wykrywania kolizji. W tym świecie mogą odnaleźć różne elementy Modułu opisane w Książce Kolizji; • Platforma Moodle z interaktywnymi filmami instruktażowymi; • Plik BIM w formacie IFC zawierający model budynku z kilkoma kolidującymi elementami do odnalezienia; • Prezentacja online w postaci Książki Kolizji dotycząca zagadnień teoretycznych stojących za wykrywaniem kolizji; • Testy online do samodzielnego sprawdzenia wiedzy i umiejętności użytkownika.
Język	angielski
Metody dydaktyczne	Samodzielnie prowadzony moduł online zawiera testy, zadania i interaktywne filmy instruktażowe z zadaniami do wykonania, w duchu gamifikacji, która angażuje użytkowników na poziomie wraże użytkownika. Zadania w filmach wymagają pracy użytkownika, ponieważ są poprzedzone jedynie pokazaniem analogicznych czynności, ale nie pokazują dokładnego rozwiązania. W przypadku błędnej odpowiedzi użytkownik otrzyma podpowiedź, ale rozwiązanie nadal zależy od niego. Dopiero gdy odpowiedź będzie poprawna, pojawi się możliwość kontynuowania filmu.
Metody weryfikacji efektów uczenia się	Samoocena: pre-test, post-test, interaktywne filmy z zadaniami. Ponieważ Moduł koncentruje się na części architektonicznej/budowlanej, uczestnicy będą pracować na gotowych plikach, na których będą musieli wykonać zadania. Pliki robocze będą zawierały określoną liczbę kolizji, dlatego odpowiedź na zadanie może być wartością liczbową odpowiadającą liczbie znalezionych elementów, ich powierzchni lub objętości. Możliwe są również odpowiedzi typu "tak/nie". Rozwiązanie testu i udzielenie poprawnej odpowiedzi podczas samosprawdzania pozwoli uczącemu się

	na kontynuację, a więc Moduł staje się samodzielny pod względem oceny postępu użytkowników.
Metody ewaluacji Modułu	ankieta

Table 8.29 Digital Calculation Module Syllabus in Polish

Nazwa Modułu	**Kosztorysowanie w BIM (Digital Calculation)**
Typ	online
Liczba godzin	40 godzin
Instytucja / Autorstwo Modułu	Halmstad University, Department for Energy and Construction Engineering
Wymagania wstępne	Studenci lub profesjonaliści z sektora AEC
Opis treści Modułu	**Przegląd i opracowanie procesu kosztorysowania w budownictwie** **Cel: podstawowa wiedza na temat kosztorysowania w kontekście procesowym** a) Nauka (Learning-Input) • Przegląd cyfrowego procesu budowlanego i jego zalet • Proces przetargowy i kosztorysowy • Cyfrowy proces przetargowy i kosztorysowy b) Przegląd oprogramowania i cyfryzacji w praktyce • Przegląd typowego oprogramowania i demonstracje procesów cyfrowych c) Ocena • Ocena i przegląd gotowych kosztorysów
Efekty uczenia się	Po pomyślnym ukończeniu modułu student zdobędzie następujące umiejętności praktyczne: a) Praktyczny wgląd w narzędzia do cyfrowego kosztorysowania Po pomyślnym ukończeniu modułu student zdobędzie następującą wiedzę: a) Wiedza na temat cyfrowego procesu konstrukcyjnego oraz jego wad i zalet b) Wiedza o cyfrowym kosztorysowaniu oraz jego wadach i zaletach

Materiały dydaktyczne	a) Wykłady dotyczące tematyki Modułu b) Demonstracje cyfrowych narzędzi do kosztorysowania
Język	angielski
Metody dydaktyczne	Nagrane wykłady: Cyfrowe przeglądy treści nauczania Demonstracje oprogramowania Quiz dotyczący wykładów i demonstracji
Metody weryfikacji efektów uczenia się	Quiz
Metody ewaluacji Modułu	Ankieta, anonimowy feedback na Moodle

Table 8.30 BIM Energy Calculation and Evaluation Module Syllabus in Polish

Nazwa Modułu	**Kalkulacja i ocena energetyczna budynku w BIM (BIM Energy Calculation and Evaluation)**
Typ	online
Liczba godzin	10 godzin
Instytucja / Autorstwo Modułu	Institute for Research in Environment, Civil Engineering and Energy, Skopje
Wymagania wstępne	Studenci lub profesjonaliści z sektora AEC
Opis treści Modułu	**Wykorzystanie narzędzi BIM do poprawy charakterystyki energetycznej budynku** a) Cele optymalizacji charakterystyki energetycznej budynków b) Faza projektowa • Rola i znaczenie etapu projektowania w optymalizacji efektywności energetycznej • Wyzwania dla projektantów • Wybór zrównoważonych materiałów i produktów przy użyciu BIM • Wiedza i umiejętności w zakresie BIM i efektywności energetycznej potrzebne projektantom c) Faza budowy • Rola i znaczenie etapu budowy w cyklu życia budynku w aspekcie ogólnej optymalizacji efektywności energetycznej

	• Wykorzystanie BIM na etapie budowy do optymalizacji charakterystyki energetycznej budynków • Wiedza i umiejętności w zakresie BIM i efektywności energetycznej potrzebne pracownikom budowy d) Faza użytkowania • Rola i znaczenie etapu użytkowania w optymalizacji efektywności energetycznej • Wykorzystanie BIM na etapie użytkowania w celu poprawy charakterystyki energetycznej budynków **Opracowanie Modelu Analizy Energetycznej** Przewodnik krok po kroku dla rozwoju Modelu Analizy Energetycznej i analiza energetyczna budynku mieszkalnego
Efekty uczenia się	W zakresie umiejętności praktycznych, po pomyślnym ukończeniu modułu student zdobędzie umiejętności: a) Wykorzystanie schematu pracy nad modelem BIM do obliczeń i oceny charakterystyki energetycznej budynków b) Poznanie metody tworzenia na etapie projektowania Modelu Analizy Energetycznej na podstawie modelu BIM 3D W zakresie znajomości teorii, po pomyślnym ukończeniu Modułu, student pozna następujące zagadnienia: a) Opisanie wykorzystania narzędzi BIM do optymalizacji charakterystyki energetycznej budynków w ich całkowitym cyklu życia b) Wskazanie wymaganej wiedzy i umiejętności w zakresie BIM i efektywności energetycznej dla projektantów, pracowników budowy oraz zarządców zajmujących się eksploatacją i utrzymaniem budynków c) Wyjaśnienie roli różnych użytkowników i określenie wyzwań na etapie projektowania, budowy i eksploatacji
Materiały dydaktyczne	Prezentacje; samouczki internetowe; linki do samokształcenia kierowanego; wytyczne do wykorzystania zestawów narzędzi do analizy energetycznej budynków; studia przypadków
Język	angielski
Metody dydaktyczne	Przedstawienie ogólnego przepływu pracy nad rozwojem modelu energetycznego budynku, w tym przewodniki z kolejnymi krokami

	i punktami kontrolnymi, w celu zapewnienia zgodności z modelem architektonicznym; podstawy optymalizacji alternatyw projektowych; możliwość powielenie w innych środowiskach oprogramowania BIM
Metody weryfikacji efektów uczenia się	Quizy (oceniające poziom zrozumienia i wykorzystania narzędzi BIM do oceny efektywności energetycznej)
Metody ewaluacji Modułu	Ankieta, anonimowy feedback na Moodle

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