



BIM-enabled Learning Environment (BLE) – Open Learning Resources

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Executive Summary

The aim of this document is to explain the requirements, system design, development process and use procedures for the Open Learning Resources (OLR) repository as an integral part of the BIM-enabled Learning Environment (BLE) developed under the BENEDICT project.

The Open Learning Resources (OLR) repository is intended to provide a database of BIM models and other sources of information that can be used by teachers and learners for BIM-enabled learning activities via the BIM-enabled Learning Environment (BLE) platform. OLR are Open Educational Resources, i.e., learning, teaching and research materials in any format and medium that are publicly available for open access such as text, media, and other digital assets. For BIM-enabled learning, these typically take the form of case studies of buildings / facilities that have been designed and engineered in industry or in the educational environment, for example, in previous courses. Thus, while the BLE platform offers teachers and learners the necessary functionalities to carry out BIM-enabled learning, the OLR repository is the integrated database of learning resources that enables this.

In developing the OLR repository, a central challenge was to establish an effective system of classification to describe (and thus make searchable and accessible) the BIM models, model elements and other materials that constitute the OLR. The possibility to navigate the OLR repository is of critical importance and it depends on data format and BIM object categorization. BIM models can be classified as types of models and model elements. All models are composed of model elements that have properties and attributes, and each different BIM authoring tool, as well as the OpenBIM IFC file format and classification system, has its own unique terminology to describe these components. Due to the complexity of buildings, a sophisticated ontology is required to develop an understanding of how model elements may relate to one another.

Within the BENEDICT project, the requirements for the OLR repository were identified and analysed before the development of the server and repository commenced. A Beta version of the repository was first presented to stakeholders, then a first online version (<https://giadeit.com>) was presented and accessed by consortium partners before the final version of the OLR repository was released which has been fully online and hosted on a Unibo server (with the address <http://ble.unibo.it>) from July 2023.

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1 Introduction to the development of BIM-enabled Learning Environment (BLE) Open Learning Resources Repository

1.1 Background and purpose

Digitalisation is transforming the real estate and construction sector (REC) in a profound manner. The professionals of the sectors, companies, institutions, buildings, and infra-structures together with users are becoming data generators and data users. The physical built environment is to be equipped with digital twins providing mirror representation of physical facilities for the purposes of their monitoring, planning and management.

Along this transformation the education also must adapt. In the big picture, the impacts on education have been rather limited and the potential of digitalised solutions is still largely unrealised. When the companies are often presenting their needs to get skilled people regarding certain software solutions the natural response from educational institutes has been to provide specific education around such tools. These services have been added into the content of existing curriculums without any profound changes to the curriculums themselves.

Clearly, there is a need to reshape the education solutions for the REC sector with digital technologies. The education of different professionals in this sector have naturally already well-established solutions together understanding over different skills and qualifications that are required. But now with digital technologies these skills can be taught and learned in new ways. Whether this is about city planners, architects, structural engineers, construction project managers or HVAC instructors (or any other professionals) the use of digital models can provide a completely new landscape for the education of these professionals.

The purpose of the BIM-enabled Learning Environment (BLE) is to provide starting point for renewing the educational solutions in the REC sector (Witt & Kähkönen, 2019A; Witt & Kähkönen, 2019B). The partners of the BENEDICT project have developed the BLE prototype that is demonstrating the possibilities of new educational solutions.

The BENEDICT project deals with how to teach courses at university level with BIM Building Information Modelling tools, in particular through the use of an IT platform for BIM models (Olowa et al. 2022, Ruutman et al., 2022, Witt & Kähkönen, 2019B). The fundamental needs of REC professionals (Architects, Engineers, Construction Managers, etc.) and students, concerning Building Information Modelling involve the design, development and implementation of various building and management systems, for instance:

- Architectural systems and space coordination; i.e architectural layout and spatial units (size and coordination, proximity relationships, internal partitions),
- Structural systems; foundations, poles, structural slabs and basement structures, superstructure, reinforced concrete framework, GLT and solid timber frame, CLT and prefabricated panels, floors and roof structures;
- Enclosure systems; architectural language and facades, doors and windows, architectural finishes, waterproofing, roofing;
- Mechanical /Electrical / Plumbing - MEP systems; connection systems i.e. elevators, mobile staircases,
- Construction project systems; construction site provisions and equipment (e.g. scaffoldings, tower crane, formworks etc.).
- Project Construction Management systems; project control methods and tools concerning project description, integration and implementation, project planning and time management, project risk management, project cost, quality and resources management.

The needs of BLE users – learners, teachers, system administrators – consist in having the availability of data, reports, pieces of information concerning architecture – engineering systems. The technical data and information concerning

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design, development and installation of the building and its project management allow BLE users to create the Building Information Model. For example, construction management students will need a set of case studies to be tested with practical exercises and the Open Learning Resources will provide these as actual case studies - each case study consisting of a building or facility that has been designed and engineered in industry or in previous courses. Learning experiences using these will greatly enhance BIM-enabled learning where BIM-based workflows will provide immersive learning and training opportunities. BIM-enabled learning can use a virtual platform, a web site and repository, where all BIM models, examples and data can be stored and used. This creates the BIM-enabled Learning Environment (BLE). The BLE provides the learning environment or web platform specifically designed to support this type of learning. Key resources for the use of the BLE are Open Learning Resources.

1.2 Objectives and scope

The main objective for the Open Learning Resources repository is to give access to a set of BIM models and other sources of information that can be used by teachers and learners for the implementation of the BIM-enabled learning, via the BLE platform.

This is a multifaceted challenge where various specific objectives need to be successfully reached. The following summarises those objectives:

- The development of the BLE platform prototype comprises the design, data formats, protocols, functionalities, and IT-solution which constitute a common, open learning environment for the education of various professionals.
- BLE is to act as a repository of learning materials, and which will host the open learning resources (Intellectual Output O3) and pilot modules (Intellectual Output O4) developed as part of the BENEDICT project.
- A specific server to store learning materials, BIM models, plans, Scope of Works, and other project data has been developed as part of the outputs of the Intellectual output O3.
- The resultant BLE platform will be the infrastructure for having a systemic solution for BIM-enabled learning. This refers here to unfolding the possible avenues for education and training where building information modelling (BIM) and its results are utilized in a pervasive manner for the learning benefits of new and existing professionals.
- The BLE platform integrates BIM technologies and their learning with traditional design and engineering studies rather than having separate modules and courses for learning BIM skills.
- Continuing education is of relevance for updating the skills of experienced professionals.

The scope of the BLE solution is broad since it is targeted towards different educational needs. This is addressed via its three educational dimensions of BLE: Spectrum, Modes and Extent.

The educational **SPECTRUM** presents the various contextual dimensions that are covered by the BLE platform. Those are:

1. **Building modelling and production of good quality models** that are useful in different phases of construction projects. This covers different design and engineering disciplines (e.g. architecture and geotechnical, structural and building services engineering). Various BIM analyses, such as visualizations/VR/AR experiments for end users and clients, structural optimization, sustainability and energy efficiency analyses, are in a growing manner an inbuilt feature of modelling itself.
2. **The use of resultant building models** for numerous tasks and needs in construction operations (e.g. quantity take-off, cost estimating, scheduling, procurement and supply management).

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3. **The interplay and its processes for effective collaboration** between different parties in a BIM intensive construction operation.

The educational **MODES** present the main pedagogical solutions that are present in the BLE platform

1. **Demonstrational teaching** via E-learning and/or Open Course Ware (OCW) lessons. Educational packages for independent studies.

2. **Learning by doing**. Interactive learning according to a systematic study program where instructors and students are linked to each other in a consistent manner for follow-up studies, providing reflections and feedback.

3. **Collaborative learning by project work**. Students are together experiencing a simulated construction project and work in such an environment. This is seen as most advanced educational form where students rather than as a stand-alone exercise can experience the dynamics and complexity of BIM intensive construction projects. These courses can particularly enhance knowledge and competence on project work practices, collaboration with different parties, design meetings, dialogue and problem-solving skills.

The educational **EXTENT** presents the main ways how the BLE platform is entering the built environment profession:

1. **Academic BIM studies**: for different degree programmes (BSc., MSc.) in a single university or for having joint educational courses/modules between universities.

2. **Continuing education**: for universities or other educational and training institutions organising studies on topical matters of interest to professionals.

With its IT solution, the BLE platform provides:

1. **Open learning environment for BIM-enabled education**: solutions are to be open and software vendor independent, and they are to be available for the use of educational and training institutions throughout the Real Estate and Construction (REC) sector. The building models used will be according to open BIM standard and principles; these models shall be available in a standard interoperable format (ifc).

2. **Repository of building models and relating learning resources** (as described in the present report and developed as Intellectual Output O3). This includes presentation of educational pilot modules (developed as Intellectual Output O4) and their use.

3. **Available online services** via Internet.

1.3 Methodology of the development of the Open Learning Resources (OLR) repository

The methodology behind the development of the repository of building models and relating learning resources is described in the following.

The simulation of actual design and project management activities that takes place in teaching REC modules with BIM as a medium has the need of a Common Data Environment where data, building objects and models, and other digital documents and information materials can be stored and used. A Common Data Environment (CDE) is a single source of information for any given project, used to collect, manage, and disseminate all relevant approved project documents for multidisciplinary teams in a managed process (ISO 19650). A CDE has four different environments where models and data can be stored: the work in progress area, the shared area, the published area and the archive (fig.1).

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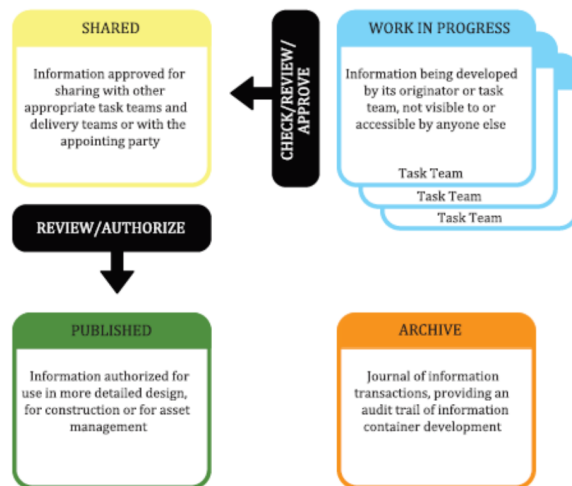


Fig.1 Common Data Environment concept (ISO 19650-1)

With the aim of creating a virtual environment for learning and teaching activities two different virtual environments were developed, the BLE platform and the OLR repository. The OLR repository is not a CDE because it does not fulfil all the requirements of the ISO 19650 standard, but it was developed with the aim of storing BIM models, data and information materials. The BLE platform and repository together create a virtual environment where teachers, learners and system administrators can store data, reports, pieces of information concerning architecture and engineering systems of the built object under design. All of these needed technical data and information concerning the different stages of production of a building, design, i.e. concept design, space coordination and technical design, construction and installation, operation and maintenance allow users to create the Building Information Model. Construction Management students, as an example, will need to use a set of case studies to be tested with practical exercises.

Open Learning Resources (OLR) will be supplied as actual case studies – each case consisting of a building or a facility that has been designed and engineered in industry or in previous courses. The BLE, will be used to store and manage both OLR and BIM models, output of the students’ work. Therefore, the BLE will provide a virtual environment where educational activities in the REC sector can be performed using BIM-based technology.

Open Educational Resources (OER) are learning, teaching and research materials in any format and medium that reside in the public domain or are under copyright that have been released under an open license, that permit no-cost access, re-use, re-purpose, adaptation and redistribution by others (UNESCO, 2019). OER are freely accessible, openly licensed instructional materials such as text, media, and other digital assets that are useful for teaching, learning, and assessing, as well as for research purposes. The term "OER" describes publicly accessible materials and resources for any user to use, re-mix, improve, and redistribute under some licenses. These are designed to reduce accessibility barriers by implementing best practices in teaching and to be adapted for local unique contexts.

The BENEDICT project has the aim of promoting a new concept of learning/training in the REC sector. The OLR are essential for users to benefit from the BLE as they provide real (or near-real) project data for learners to work with and this will demonstrate the practical implementation of BIM workflows. The BLE creates a repository of OLR that can be descriptions of projects, technical BIM models and objects, and project plans (table 1).

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OLR	Examples	File format
Descriptions of projects	project objectives; site description and analysis; media concerning the site; building overall concept description; statement of work (sow); building systems reports, drawings and calculation	.docx; .xlsx; .pdf; .dwg; dxf; xml; mp4; JPG
Technical BIM models	BIM objects; BIM model	.ifc
Project Plans	architecture and envelope layout; structure layout; MEP systems layout, construction process. bills of quantities; budgets; schedules; resource estimation, procurement documentation concerning materials, products, components and other supplies; safety plans	docx; .xlsx; .pdf; .dwg; dxf; xml; mp4; JPG

Table 1: Type of Open Learning Resources for the Benedict Project.

Open learning resources (OLR) for BLE need to be checked before model processing. The BIM models should be checked also concerning the achievement of the desired level of detail / level of development (LOD) and quality assessment consisting in code checking and model checking. The purpose of defining the level of information need is to prevent delivery of too much or too little information (ISO 19650-1:2018). In particular, the Project Information Requirements (PIR), in relation to the delivery of an asset indicate for what, when how and for whom information is to be produced. The Level of Information Need (LOIN) must be set by applying the BS EN 17412-1 that indicates the framework to set the LOIN. Firstly, four pre-requirements addressing the context needed to identify the information content that has to be set: BIM uses, milestone, actors, object. After this stage, the LOIN must be set concerning geometrical information, alphanumeric information, and documentation (BS EN 17412-1:2020) (fig. 2, fig. 3). In the specific case of construction management – oriented applications, OLR will be supplied to students and applicants as actual case studies. Each case study consists in one or more than one building or civil engineering facility that has been designed and engineered in previous courses of the university programme, or provided by teachers or by the BENEDICT project associated partners. As an example, the following documentation / information materials can be produced by the students of construction engineering and management courses with Building Information Modelling.

- Project Planning, job site design & safety planning:
- Work Breakdown Structure.
- Construction project schedule
- Construction site design
- 4D BIM animation

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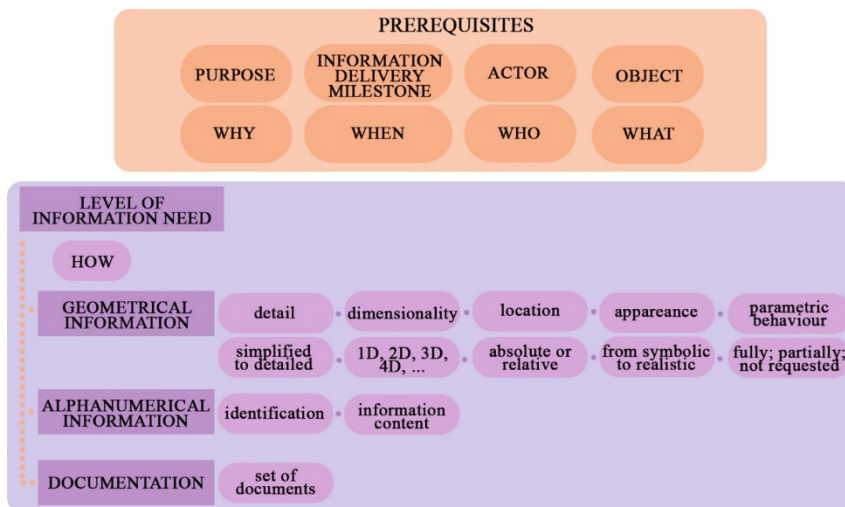


Fig. 2: Relationship diagram on level of information need.

LOD 100	LOD 200	LOD 300/350	LOD 400	LOD 500
Concept phase	Conceptual design	Tender project	Construction state project	As built project



Fig. 3: Example of the concept of "continuum" associated to the detail of a door.

1.4 Structure of the report

This report is the main BENEDICT document explaining the development of the BLE Open Learning Resources (OLR) repository. The main content of this report comprises

- Introduction to the development of BLE Open Learning Resources repository
- Development starting points and principles
- The system architecture for BLE platform and OLR repository
- Conclusions

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2 Development starting points and principles

2.1 The BLE and OLR Categorization

The BIM-enabled Learning Environment (BLE) is a virtual environment which integrates BIM strategy and technologies into curricular activities, i.e. course modules. The BLE environment consists of the BLE Platform, that hosts the pilot modules teaching and learning materials, and an OLR repository that includes a Content Management System and a server that hosts BIM models and other OLR (fig. 4).

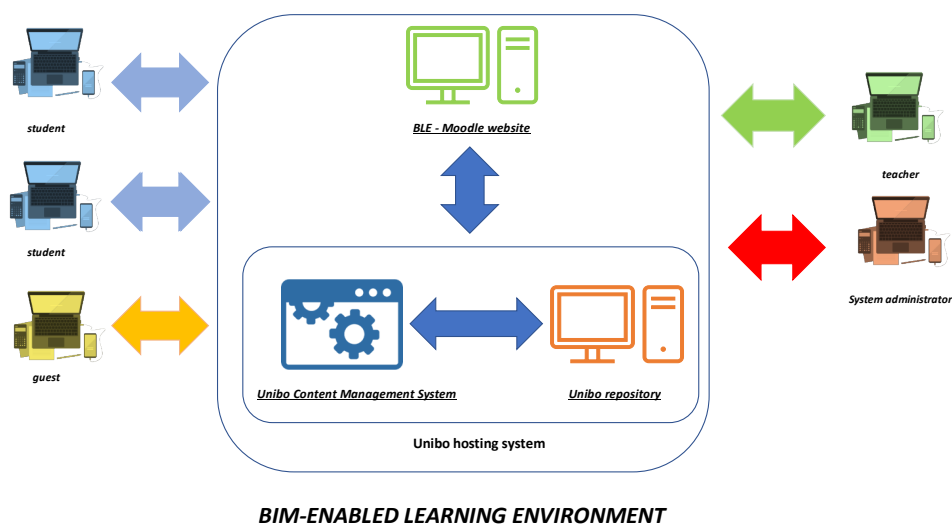


Fig. 4: BIM-enabled Learning Environment (BLE) – system architecture.

In the BLE platform (<https://www.bim-enabled-learning.com/ble/>) the pilot modules section addresses the three different pilot modules of the BENEDICT project: Design Management, Risk Management, and Time Management module (fig. 5). The repository (<http://ble.unibo.it> fig. 6) includes a Content Management System CMS and a Data Base (DB) for storage of OLR and students' outputs, (fig. 6). Both sections can be used by different actors with different navigation capacities depending on the type of user: teacher, learner, and system administrator (fig. 6).

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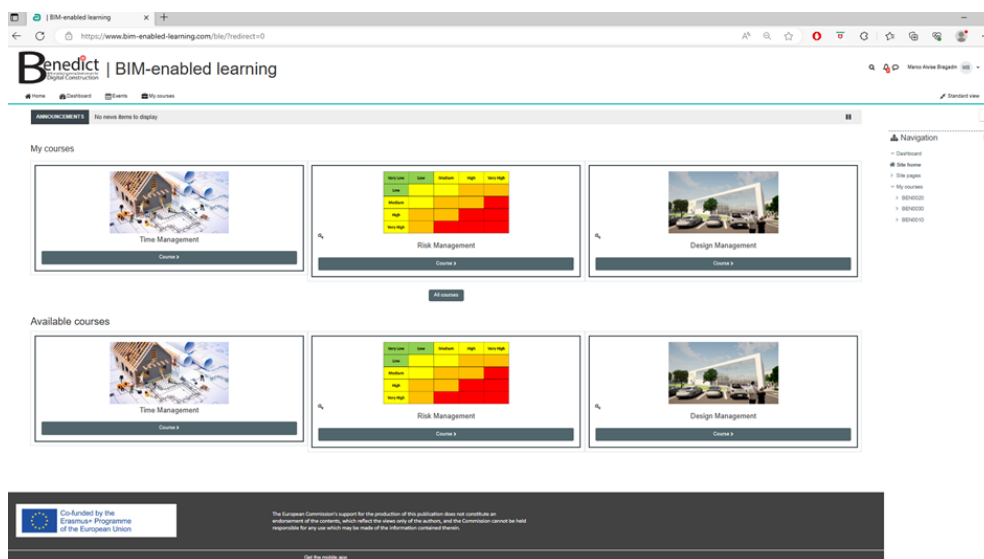


Fig. 5: BIM-enabled Learning Environment (BLE) – BLE platform.

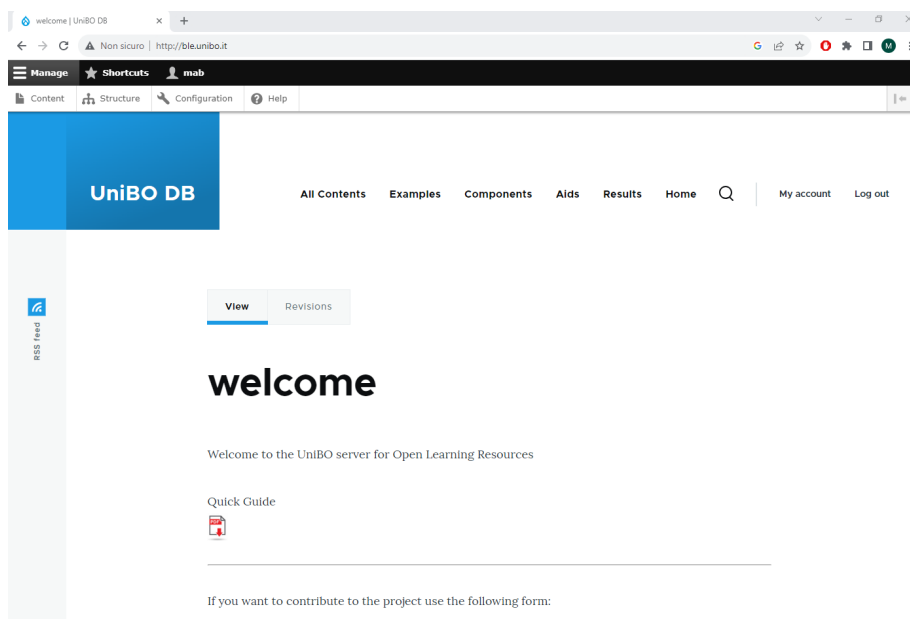


Fig. 6: BIM-enabled Learning Environment (BLE) – OLR repository.

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2.2 The OLR Categorization and the navigation capacity

Construction professionals and students (Architects, Engineers, Construction Managers) need BIM for various building and management systems:

- Architectural system
- Structural system
- Enclosure systems
- Mechanical/Electrical/Plumbing systems
- Construction systems: construction site provisions and equipment (e.g. scaffoldings, tower crane, formworks etc.).
- Project Construction Management systems: project control methods and tools concerning project description, integration and implementation, project planning and time management, project risk management, project cost, quality and resources management.

The simulation of actual design and project management activities that take place in teaching REC modules with BIM as a medium have the need of a common repository, termed the BIM-enabled Learning Environment (BLE). All of these technical data and information concerning the different stages of production of a building, design, i.e., concept design, space coordination and technical design, construction and installation, operation and maintenance allows user to create the Building Information Model. Open Learning Resources (OLR) will be supplied as actual case studies and the BLE provides a virtual environment where educational activities in the REC sector can be performed using BIM-based technology. The OLR repository plays a fundamental role in this, and its efficiency depends on the OLR categorization that allows users to find quickly all the needed resources.

The navigation capacity is of capital importance as it depends on data format and BIM object categorization. BIM models can be classified as types of models and model elements. All models are composed of model elements that have properties and attributes. Each native BIM authoring tool, as well as the OpenBIM IFC file format and classification system, use their own unique terminology to describe these components. It is therefore important to first understand what is considered an element and how elements relate to one another in order to discuss them.

Due to the complexity of buildings and BIMs, a simple hierarchy does not suffice to describe the relationship between model elements (US GSA BIM Guide 07). A sophisticated ontology is required to develop an understanding of how model elements may relate to one another. All the levels in the model ontology have properties associated with them, and thus the properties of one model element are associated with related model elements. A BIM ontology is an informal, semi-structured, conceptual domain ontology used for knowledge acquisition and communication between people (fig. 7).

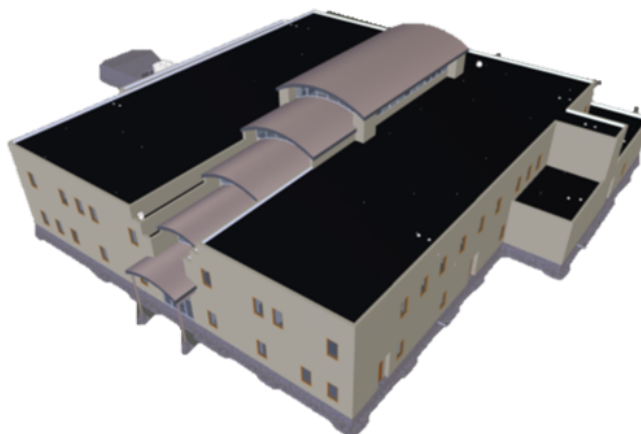


Fig. 7: Federated Model (from US GSA BIM guide 07).

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The framework for classification of ISO 12006 about construction works also introduces a set of different relationships between the different classes of information. The organization model or user activity of the built asset uses the built space that is defined by a construction result, that is part of a construction complex. A construction complex is an aggregate of construction entities, composed by construction elements. A construction result is developed by a construction process that is divided in pre-design, design, production and maintenance processes. Construction process uses construction resources that can be construction product, construction aid, construction agent and construction information (ISO 12006-2:2015). Classifying data means structuring it in an agreed way so that different actors can easily find what they need and understand it. A classification system is like a common language. In BIM, classification lets people, software and machines share and use building information efficiently and accurately. Different classification systems have been developed for different types of BIM data and actors, and for different geographic areas and situations. In table 2 some other examples of BIM classification are presented.

As a first approach the following classification systems for OLR were proposed for the BLE platform classification systems: metadata, building type, size of the project, different plans, life cycle period, model categories, model functions, language/country. Metadata classification was chosen as the easiest way of OLR categorization. Many metadata of BIM models can be detected, and different categories of information can be listed in the repository for each piece of OLR. Again, a list of metadata of BIM education models is presented in table 2.

The BIM-enabled learning environment is a prototype for online BIM models repository (fig. 5 and fig. 6). The proposed categorization system of BIM models is based upon five categories: discipline, type of building project, life cycle stage, model use and BIM object.

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Table 2: Metadata of BIM education Models.

Information Category	Value Type	Values	Description
Model Language	Text	English, Finnish, Estonian, Italian	The language(s) used in the model to describe the content
Building Type	Text	Office, Teaching, Care, Residential	Property used to describe the dominant function/use case for the facility
Discipline	Text	Urban, Architecture, Landscape, Interior Design, Structural Engineering, Building Services Engineering (HVAC and MEP), Construction Engineering, Facility Maintenance	The model discipline prepared by or for the purpose of the given discipline.
Program	Text	Small, Medium, Large	Reflecting on the size of the building, relative to its building type.
Model Categorization	Text	Mass, Room/Space/Zone, and Element models	The type of model content
Life-Cycle Stage	Text	Strategic Planning, Brief, Programming, Schematic Design, Preliminary Design, Design Development, Detailed Design, Pre-Construction, Construction, Commissioning, Hand-Over, Use, Renovation, Disassembly, Demolition	The stage of the model prepares in or for
Model Use	Text	Gather, Generate, Analyze, Communicate, Realize	Penn state classification for BIM uses
Model Maturity	Text	Initial, Defined, Managed, Integrated, Optimized	The mature of the model in any specific stage.
Geometry Maturity	Text	Symbolic, Generic, Detailed, Fabrication	Average accuracy of geometry in the model.
Model Information Reliability	Text	Preliminary, Proposed, Coordinated, As-Built	The state of the information in the model, its reliability with respect to itself and others in the process
Content Classification	Text	CCI, Uniclass, Masterformat	

2.3 Creation of OLR repository

The creation of OLR repository followed the methodological logic presented in 1.3. The main activities for the development of the Repository took place in 2022 and 2023. Important milestones were the BENEDICT meetings and workshops that were arranged in January 2022 (Tampere) and in June 2022 (Tallinn), concerning the OLR categorization and the repository navigation. Directions for development and common understanding amongst BENEDICT partners were valuable achievements of these events. Pragmatic discussions around BLE pilots were also very useful for tackling various practical challenges that are typically faced in this type of education.

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Actually, the requirements of the repository were gathered in the end of 2022, and the development of the server and repository by Unibo started in the beginning of 2023, and a Beta version of the repository was presented in the E3 validation workshop of March 2023 (Bologna), while the first online version (<https://giadeit.com>) was presented and accessed by consortium partners in the C1 joint staff training event of June 2023 (Tallinn). A specific hosting system was developed and from July 2023 the final version of the Unibo server that host the CMS and the OLR repository was fully online with the address <http://ble.unibo.it> (fig. 8 and fig. 9).

Accordingly, the Unibo repository and server was gradually formed and implemented. The repository started to host learning resources and outputs of the time management pilot module in February 2023. The implementation of the repository was made by answering the previous requirements listed in the preceding stages of the BENEDICT project and the ones that emerged by implementing actual inputs and outputs of learning and teaching activities of the pilot module that was held in the first semester. Additional requirements that were considered are affordability, wide use, user friendliness, and hosting capacity. After selection of the main IT infrastructure solutions, attention was turned towards the OLR repository specific needs.

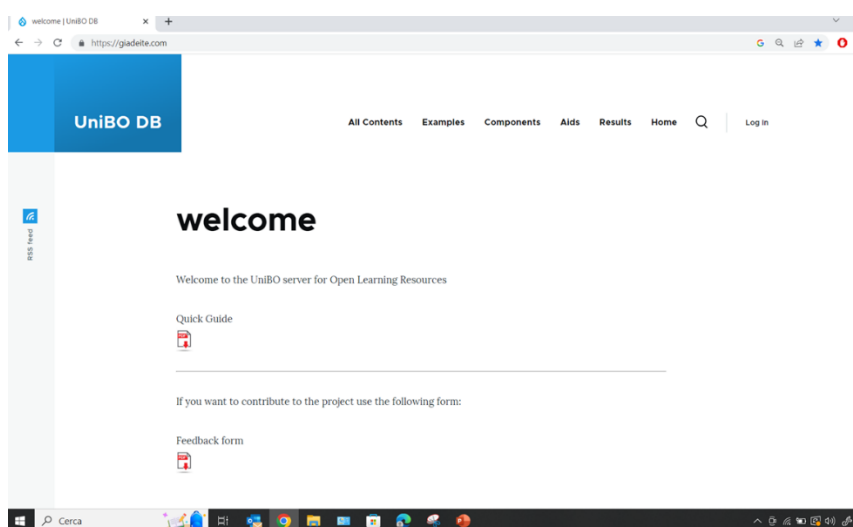


Fig. 8 BENEDICT – Unibo server and OLR repository, beta version (<https://giadeite.com>).

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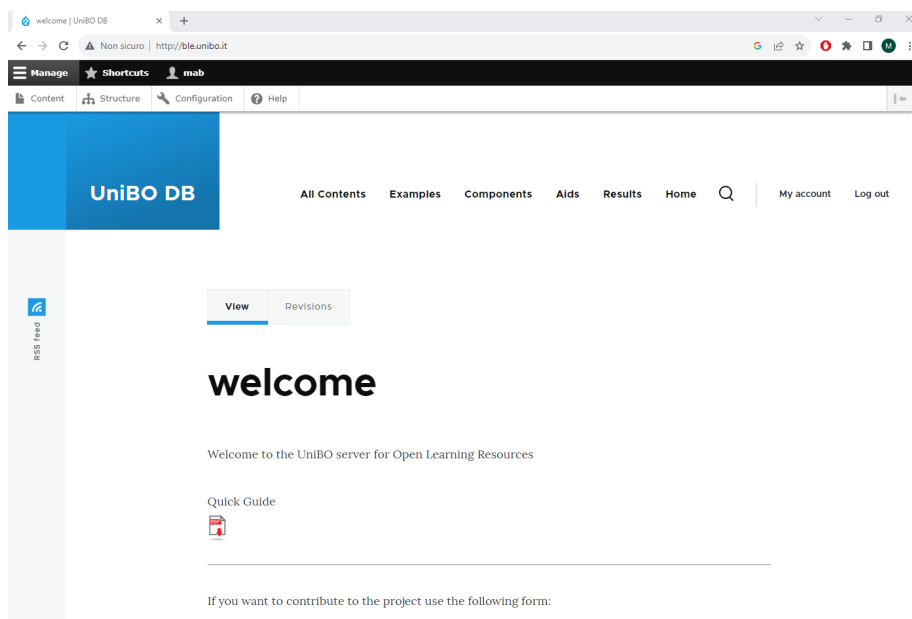


Fig. 9 BENEDICT – Unibo server and OLR repository, final version (<http://ble.unibo.it>).

3 The system architecture for BLE platform and OLR repository

3.1 The BLE concept and Unibo server

BIM models store information for each component of the project, and, therefore there is a need for making the BIM-based transfer of information between different players more effective, i.e., there is a need to help students and practitioners to implement BIM actual project models by developing an online repository of digital models, objects and elements. The most important primary concept is the BLE itself, which may be described as a:

- Platform for advancing digitalisation in the REC sector. BLE presents the wide use of BIM for different educational needs where digital models can provide learning and skills development infrastructure.
- Addressing various educational institutes (Universities, other high education institutes, vocational education, continuing education, and private training of professionals).
- Platform to enhance the education of REC sector professionals
- Offering opportunities for more immersive and integrated learning experiences.
- Including a robust IT-infrastructure
- Providing vendor independent possibilities for course and training
- Providing an OLR database that can be used by teachers and learners.

The Unibo server that hosts the OLR database was developed for the proposed online BIM models repository of the BENEDICT project. The system architecture of the Benedict BIM-enabled learning environment includes the BLE-moodle website and the Unibo hosting system. The Unibo hosting system includes a Content Management System (CMS) powered by Drupal, and a Unibo repository - <http://ble.unibo.it> (fig. 5 above).

In the welcome page (fig. 9 above) it is possible to download a guideline to help end users better use the platform . From the home page, end users can also access several sub-pages including “Examples”, fully solved BIM solutions

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that students can use as examples, “Components” or BIM objects, “Aids” including BIM documentation, standards, project data, and “Results” where students’ outputs are stored. The repository also provides a powerful searching engine to help quickly find useful information from the repository.

The Unibo DB and Content Management System CMS takes advantage of a free, open source platform, Drupal, that is easy to configure and to perform system administrator’s activities concerning user / role management, and it has no special hardware requirements and it is highly versatile (fig. 10).

3.2 The Unibo hosting system

The hosting system has the following features:

- 1 TB of storing space
- Runs on Linux
- Exposes a public web server based on Apache
- The web server interprets and runs PHP scripts
- A MySQL RDBMS is locally accessible to the applications running on the web server
- The file transfer is achievable through FTP, SFTP protocols or through web console
- The hosting system is remotely manageable through a CPANEL application
- The environment is remotely accessible through SSH protocol
- The hosting is granted for a three year period

3.3 The Unibo DB Open Learning Resources (OLR) categorization

The Unibo Server OLR categorization is the following (fig. 11):

- Examples:
 - o BIM from literature/previous courses
- Components:
 - o BIM objects
- Aids:
 - o BIM documentation
 - o Laws, regulations, standards
 - o Site plan etc.
- Results:
 - o Students’ outputs

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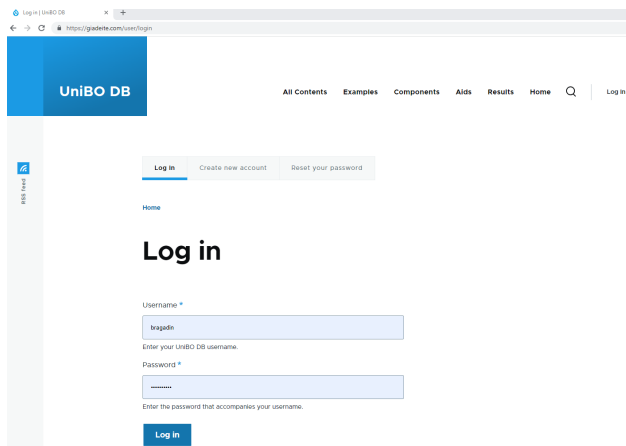


Fig. 10 UniBO server and OLR repository, log in page

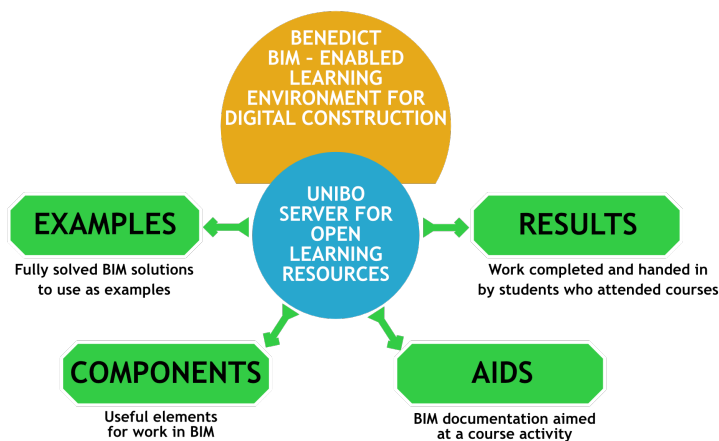


Fig. 11 UniBO server and repository, OLR categorization

There are four main categories of OLR in the UNIBO repository, examples, results, components and aids. Examples are fully solved BIM solutions to be used as examples by learners, while components are useful elements for BIM work. Aids are actual projects and BIM documentation and information materials. Results are the outputs of students' work in pilot module courses. Some examples follow:

Examples

- Construction job-site modelling: construction site provisions and equipment (e.g. scaffoldings, tower crane, formworks etc.).
- Project schedules: project planning and time management.
- Cost plans: Bill of quantities for building construction and job site safety
- 4D / 5D BIM

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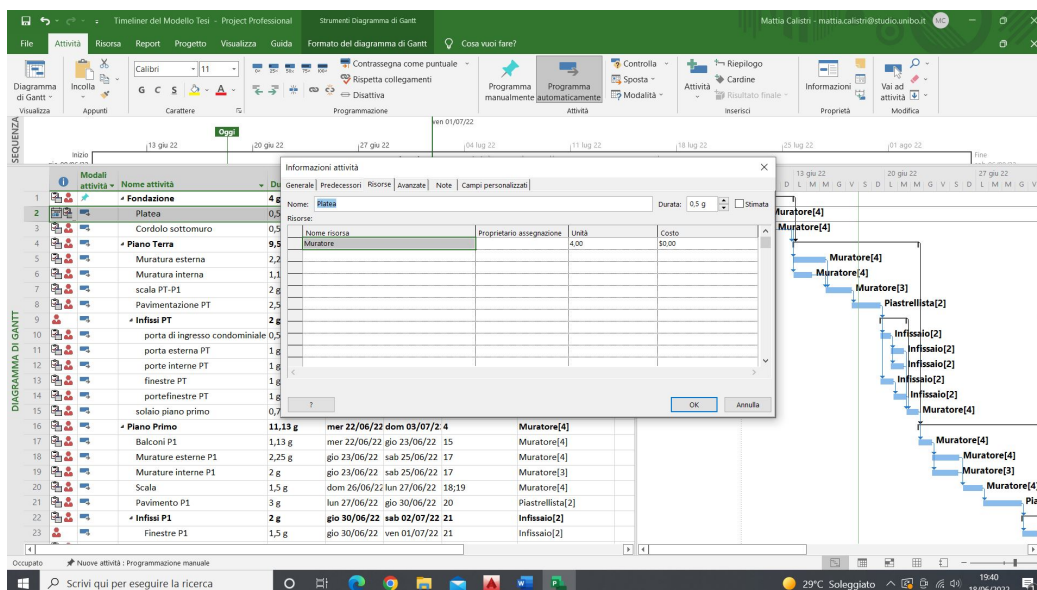


Fig. 14 Examples – outputs of previous Construction Management courses

PIANO TERZO

FASI	Importo euro	Incidenza % manodopera	Importo manodopera	Prezzo giornaliero manodopera	Giornate manodopera (U.G.)	Squadra	Unità manodopera	Durata (gg)	Durata effettiva
	da CME	da assegnare	ExF	predefinito	G/H		da assegnare	I/K	
Muratura esterna P3	2.420,25 €	40%	968,10 €	225,68 €	11,9	muratori	6	1,98	3 g
Muratura interna P3	962,12 €	40%	384,85 €	225,68 €	4,7	muratori	4	1,18	2 g
Scala P3	5.500,90 €	40%	2.200,36 €	225,68 €	27,0	muratori	6	4,50	5 g
Balconi P3	2.867,74 €	28%	802,97 €	225,68 €	9,9	muratori	7	1,41	2 g
Parapetti balconi P3	9.355,00 €	12%	1.122,60 €	225,68 €	13,8	muratori	8	1,72	2 g
Pavimentazione P3	14.998,10 €	17%	2.549,68 €	225,68 €	31,3	piastrellista	4	7,82	8 g
Infissi interni P3	1.800,00 €	18%	324,00 €	225,68 €	4,0	infissai	4	0,99	1 g
infissi esterni P3	12.000,00 €	18%	2.160,00 €	225,68 €	26,5	infissai	8	3,31	4 g
Solaio P3	18.118,55 €	22%	3.986,08 €	225,68 €	48,9	muratori	8	6,12	7 g
TOTALE	68.022,66 €		14.498,63 €						34 g

Fig. 15 Examples – outputs of previous Construction Management courses

Components:

- BIM objects and other elements for construction site modelling (fig 16, 17, 18, 19)

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Fig. 16 Components – example of BIM object for construction site modelling (rough-terrain crane)

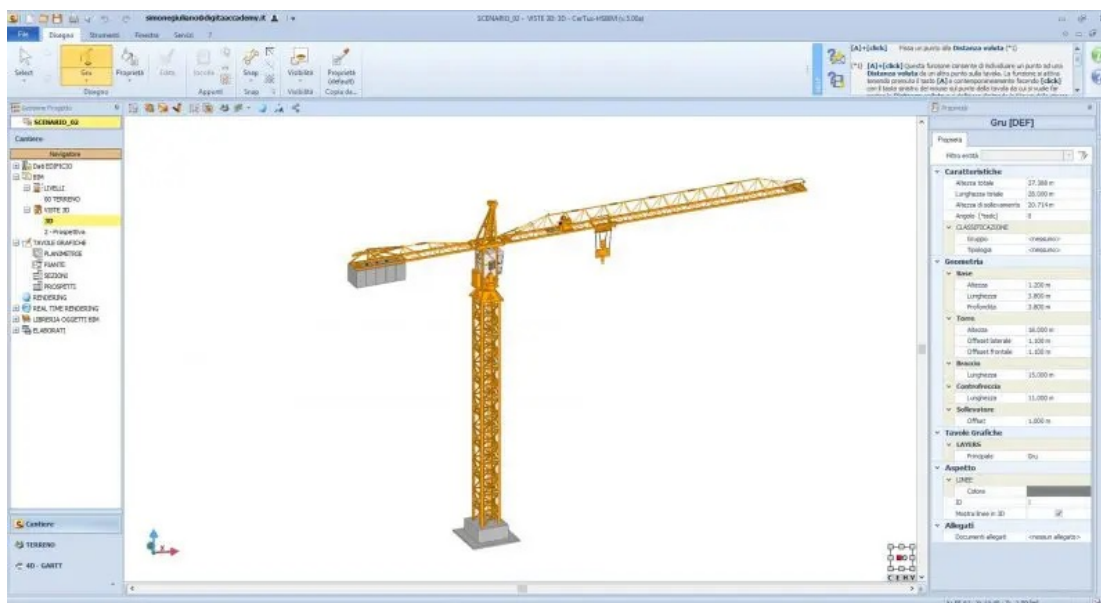


Fig. 17 Components – example of BIM object for construction site modelling (tower crane)

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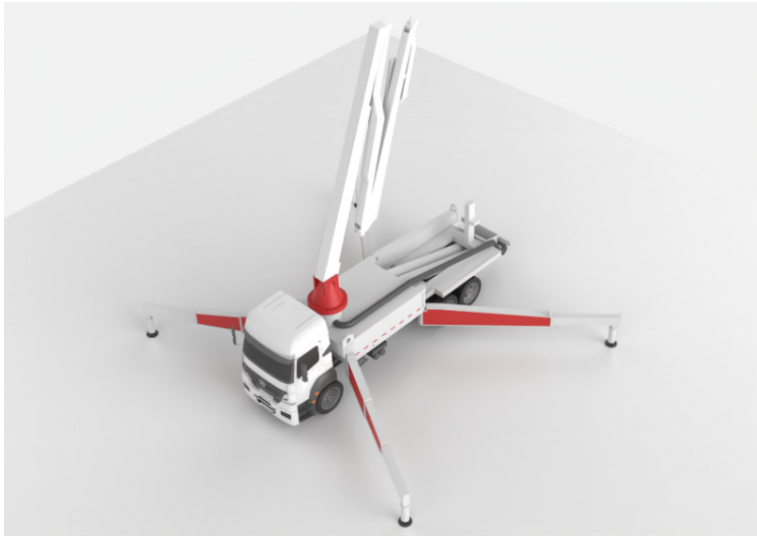


Fig. 18 Components – example of BIM object for construction site modelling (mobile concrete pump)



Fig. 19 Components – example of BIM object for construction site modelling (concrete mixer)

Aids:

- actual projects and BIM documentation and information materials (fig. 20, 21, 22, 23, 24)

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1992L0057 — EN — 27.06.2007 — 001.001 — 1

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► **B** **COUNCIL DIRECTIVE 92/57/EEC**
of 24 June 1992
on the implementation of minimum safety and health requirements at temporary or mobile
constructions sites (eighth individual Directive within the meaning of Article 16 (1) of Directive
89/391/EEC)
(OJ L 245, 26.8.1992, p. 6)

Amended by:

	Official Journal		
	No	page	date
► M1 Directive 2007/30/EC of the European Parliament and of the Council of 20 June 2007	L 165	21	27.6.2007

Corrected by:

- **C1** Corrigendum, OJ L 15, 23.1.1993, p. 34 (92/57/EEC)
- **C2** Corrigendum, OJ L 33, 9.2.1993, p. 18 (92/57/EEC)

Fig. 20 Aids – European Union council directive 92/57/EEC



Fig. 21 Aids – Cover page of the BS EN ISO 19650-1:2018 concerning BIM

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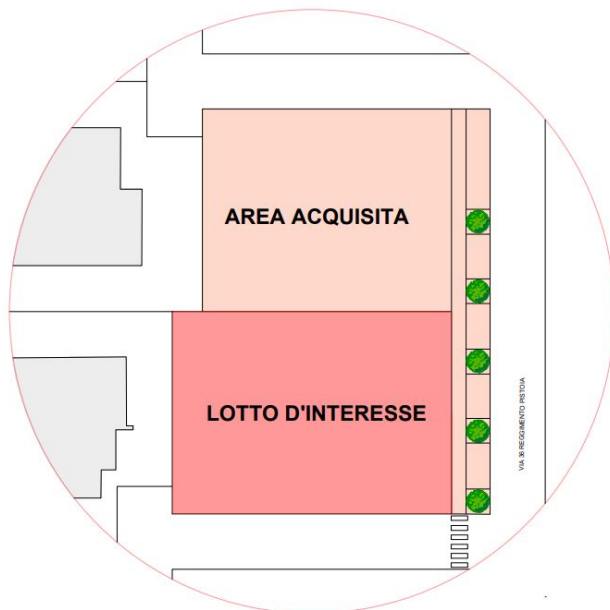


Fig. 22 Aids – Site plan for construction

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International Labour Organization
Promoting jobs, protecting people

About the ILO | Topics | Regions | Meetings and events | Programmes and projects | Publications | Labour standards | Statistics and databases

NORMLEX Information System on International Labour Standards | Search | User guide | Glossary

C167 - Safety and Health in Construction Convention, 1988 (No. 167)
Display in: French - Spanish - Arabic - German - Russian

Go to article: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44

Preamble

The General Conference of the International Labour Organisation,
Having been convened at Geneva by the Governing Body of the International Labour Office, and having met in its Seventy-fifth Session on 1 June 1988, and

Noting the relevant international labour Conventions and Recommendations and, in particular, the Safety Provisions (Building) Convention and Recommendation, 1937, the Co-operation in Accident Prevention (Building) Recommendation, 1937, the Radiation Protection Convention and Recommendation, 1960, the Guarding of Machinery Convention and Recommendation, 1963, the Maximum Weight Convention and Recommendation, 1967, the Occupational Cancer Convention and Recommendation, 1974, the Working Environment (Air Pollution, Noise and Vibration) Convention and Recommendation, 1977, the Occupational Safety and Health Convention and Recommendation, 1981, the Occupational Health Services Convention and Recommendation, 1985, the Asbestos Convention and Recommendation, 1986, and the list of occupational diseases as revised in 1986 appended to the Employment Injury Benefits Convention, 1964, and

Having decided upon the adoption of certain proposals with regard to safety and health in construction, which is the fourth item on the agenda of the session, and

Fig. 23 Aids – International Labour Organization C167 standard (Cover – online page)

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CORSO DI
CANTIERI E PRODUZIONE EDILIZIA

A.A. 2022/23

PROF. MARCO BRAGADIN



1. OBIETTIVO DEL CORSO E CONTESTO DEL SETTORE
EDILE

IL CORSO HA L'OBIETTIVO DI FORNIRE **I FONDAMENTALI**
METODI E STRUMENTI PER **PROGETTARE, ORGANIZZARE E**
GESTIRE LA PRODUZIONE NEL CANTIERE DI COSTRUZIONE
DI OPERE EDILI E CIVILI.

Fig. 24 Aids – Construction management course notes (in Italian)

Results

- Outputs of students' work in pilot module courses (job site plans, WBS, schedules, 4D BIM/ timeline animations) please see fig. 25, 26, 27, 28, 29, 30, 31 below.

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LAYOUT 1-ACCANTIERAMENTO e SCAVO

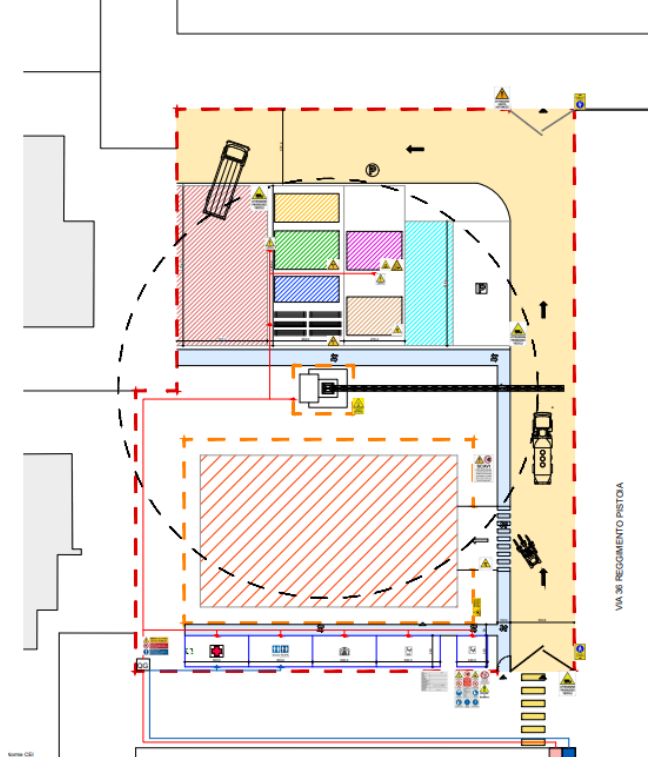


Fig. 25 Results – Construction job site plan (2D)

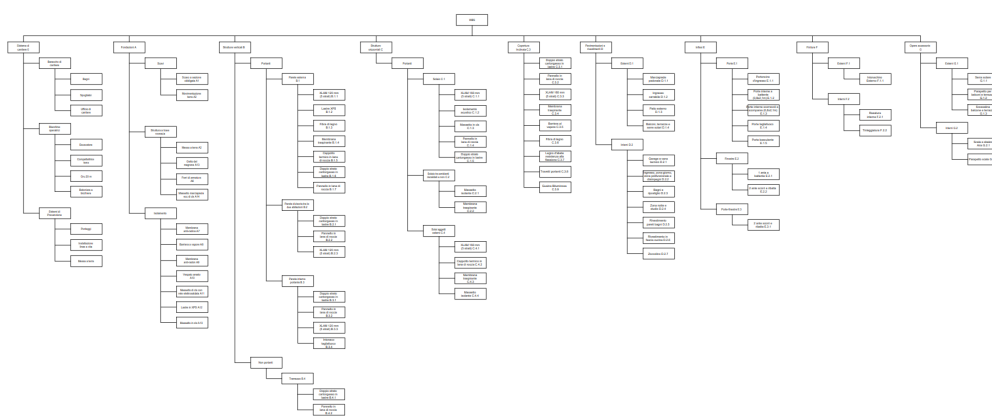


Fig. 26 Results – Work Breakdown Structure

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Fig. 27 Results – Construction schedule

Cod.	Descrizione	Unità di misura	Costo unitario	Quantità	Costo totale
Costi di sicurezza progetto A					
Prezziario di riferimento: prezziario regionale Emilia Romagna					
S.A.1	Prefabbricato monoblocco con pannelli di tamponatura strutturali, tetto in lamiera grecata zincata, soffitto in doghe preverniciate con uno strato di lana di roccia, pareti in pannelli sandwich da 70 mm, con due lamiera d'acciaio zincate e preverniciate coblenzate con podotetto espanso autoestinguente, pavimento in lastra di legno tricolore sfoderato con piano di calpestio in guaina di pvc pesante, serramenti in alluminio anodizzato con barre di protezione esterne, impianto elettrico canalizzato rispondente alla legge 46/90, interruttore generale magnetotermico differenziale, tubazioni e scatolette in materiale termoplastico autoestinguente.	cad	5.200,00 €	1	5.200,00 €
S.A.2	BOX PREFABBRICATI MODELLO PI - WC, LAVABO E DOCCIA, SERVIZI SEPARATI - 4,14 M	cad	160,00	1	160,00 €
S.A.3	Utilizzo di un chiodo costituito da box prefabbricato realizzato in polietilene lineare stabilizzato ai raggi UV o altro materiale idoneo, in ogni caso coblenzato, per garantire la praticabilità del servizio in ogni stagione; completo di impianto elettrico e di messa a terra, posato a terra su travetti in legno o adeguato sottofondo, dotato di W/O e lavabo. Sono compresi trasporto, montaggio e smontaggio, manutenzione, pulizia, espurgo settimanale e smaltimento certificato dei liquami. Noleggio mensile per i primi 30 giorni lavorativi per ogni 30 giorni lavorativi aggiuntivi	cad	110,00	6	660,00 €
S.A.4	Reazione provvisoria modulare da cantiere in pannelli di altezza 3000 mm e larghezza 3 500 mm, con tamponatura in rete elettrosaldata con maglie da 35 x 250 mm e tubolari laterali o perimetrali di diametro 40 mm, fissati a terra su basi in calcestruzzo delle dimensioni di 700 x all'esterno in opera e successivo smontaggio e rimozione a fine lavori	m	1,21 €	116	140,36 €
S.A.4	costo di utilizzo mensile verticali e orizzontali in tubolare zincato diametro non inferiore a 42 mm, pannello interno di rete zincata a caldo spessore non inferiore a 4 mm e maglia Ø5x20, peso non inferiore a 95 kg, rivestiti su un lato con rete di plastica aderente e relativi basamenti in c/c del peso di 35 kg, compresa la fornitura degli elementi, la posa in opera, l'ancoraggio al terreno (ove rappresenti struttura fissa o per linee aperte, con spessore di acciaio infissi nel terreno e legature in filo zincato, la traslazione degli elementi per la modifica della posizione e necessaria all'avanzamento dei lavori, la manutenzione per tutta la durata dei lavori stessi, la rimozione di lavori ultimati; capello cavallino da 3,5 x 3, compreso catena e baccetto - solo per il primo mese	m	0,45 €	580	261,00 €
S.A.4	pannello cavallino da 3,5 x 3, compreso catena e baccetto - solo per il primo mese successivo al	cad	43,80	1	43,80 €

Fig. 28 Results – Construction cost plan (OH & safety)

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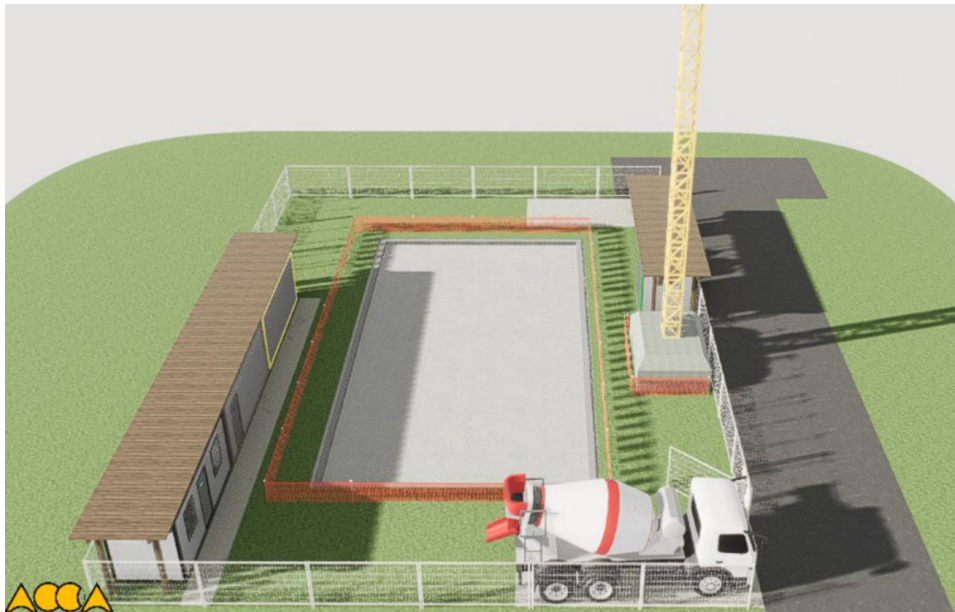


Fig. 29 Results – 3D BIM of construction stage (foundation concrete slab)

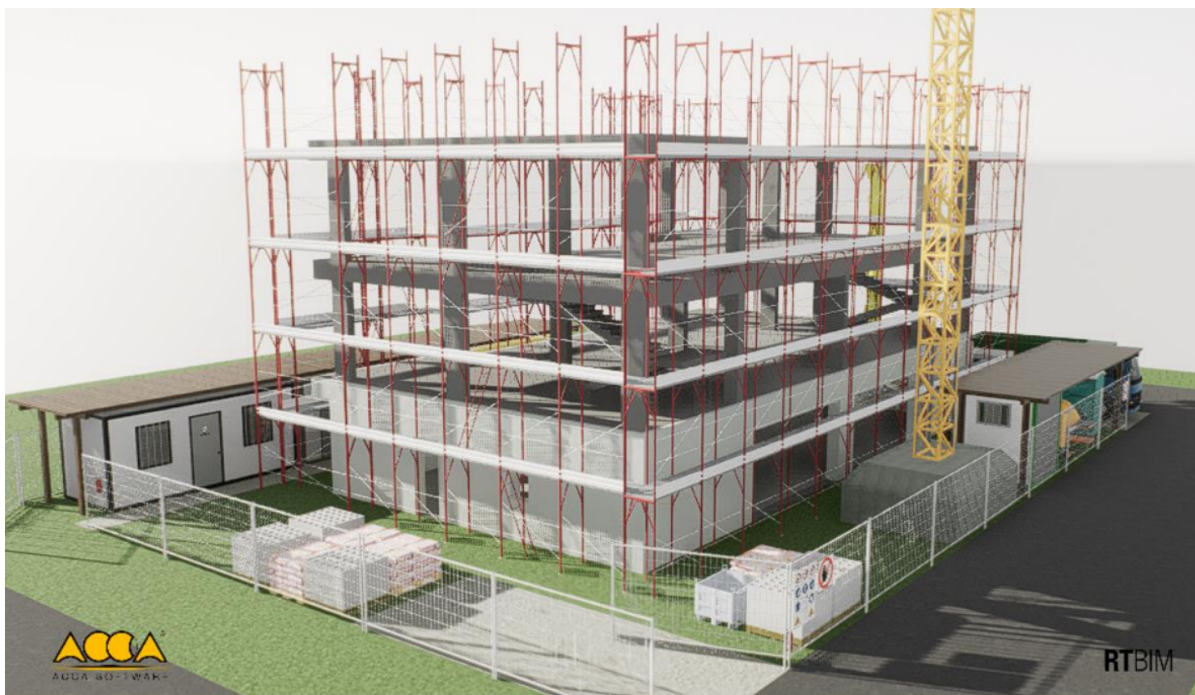


Fig. 30 Results – 3D BIM of construction stage (erection of structure and scaffolding)

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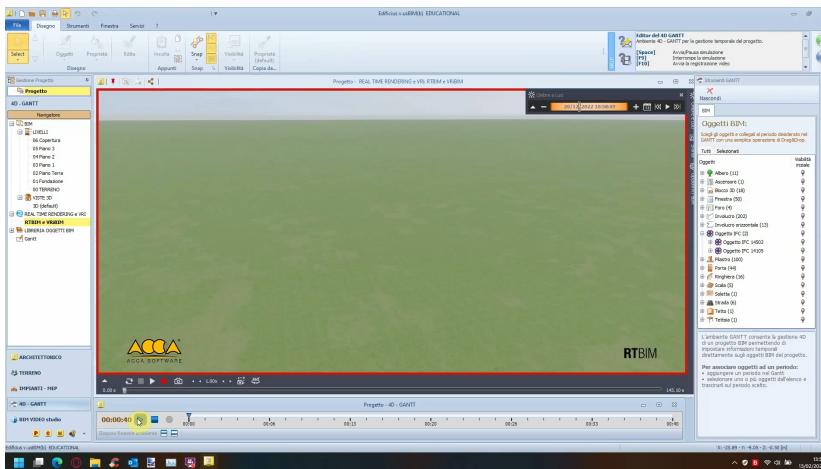


Fig. 31 Results – 4D BIM of construction stage: video timeline animation

The four categories of Learning Resources create four record types in the DB, i.e., example, component, aid and result, and each one has different sub-categorization fields. Every record type has its own fields, but generally the record fields are the following: title, type, preview image, describing text, type of file, IFC file. (fig. 32, 33, 34, 35).

EXAMPLE Record Fields

field	required	type	file format	options
title	✓	text		few words
type	✓	locked list		architecture building site engineering MEP regulation object
preview	✓	image	jpg png	
note	✓	long text		free description
file	✓	archive	.zip .7z	
IFC	<input type="checkbox"/>	file	.ifc .IFCzip	

Fig. 32 Unibo DB – Example record fields

COMPONENT Record Fields

field	required	type	file format	options
title	✓	text		few words
type	✓	locked list		template object document layout assistant schema algorithm
preview	✓	image	jpg png	
note	✓	long text		free description
file	✓	archive	.zip .7z	

Fig. 33 Unibo DB – Component record fields

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AID Record Fields

field	required	type	file format	options
title	<input checked="" type="checkbox"/>	text		few words
type	<input checked="" type="checkbox"/>	locked list		layout data
preview	<input checked="" type="checkbox"/>	image	jpg png	
note	<input checked="" type="checkbox"/>	long text		free description
file	<input checked="" type="checkbox"/>	archive	.zip .7z	

Fig. 34 Unibo DB – Aid record fields

RESULT Record Fields

field	required	type	file format	options
title	<input checked="" type="checkbox"/>	text		few words
type	<input checked="" type="checkbox"/>	locked list		architecture building site engineering MEP regulation object
course	<input checked="" type="checkbox"/>	locked list		ABS CPE ODC
preview	<input checked="" type="checkbox"/>	image	jpg png	
note	<input type="checkbox"/>	long text		free description
doc	<input checked="" type="checkbox"/>	archive	.zip .7z	
BIM	<input type="checkbox"/>	archive	.zip .7z	
3D	<input type="checkbox"/>	archive	.zip .7z	
IFC	<input checked="" type="checkbox"/>	file	.IFCzip	
video	<input type="checkbox"/>	file	.mp4	max h720 25fps 200kbps
student	<input checked="" type="checkbox"/>	text		name surname (several name?)
contact	<input type="checkbox"/>	email		email address
year	<input checked="" type="checkbox"/>	number		exam passed year

Fig. 35 Unibo DB – Result record fields

3.4 The users of Unibo DB – login & roles

The users of the Unibo OLR repository must follow different rules depending on their user role. The possible roles are the following:

- Guest account - anonymous
- Registered account:
 - Activated /students
 - Content creator /teachers
 - System administrators

Anonymous accounts have some restrictions, they can only view the web site but cannot enter the records. Registered accounts must be activated by the system administrator, and then they can upload /download and edit contents (fig. 36, 37, 38)

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welcome

Welcome to the UniBO server for Open Learning Resources



Fig. 36 Unibo DB – welcome page



Home

Access denied

You are not authorized to access this page.



Fig. 37 Unibo DB – guest account

A personal user needs to ask the administrator to activate the account to upload/download and edit contents, this is a registered account.

How to get a registered (active user) account:

- select log in (fig. 38)
- if you do not have a user yet, select “create new account” (fig. 39)
- fill email address and choose a username
- follow instructions of the e-mail sent by the system administrator

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Fig. 38 Unibo DB – log in page

Fig. 39 Unibo DB – log in page

Restrictions for the accounts:

- currently, only emails with the following domains can request to create new accounts: @unibo.it / @taltech.ee / @tuni.fi

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- every new account request must be activated by an administrator.
- every account is set on a role (i.e., student, teacher, system administrator).

Each role has different competences/restrictions:

- guest / anonymous: limited account
- activated / students: can navigate/download data
- content creator / teachers: can create and upload/download data
- administrator: can do everything.

User capacity: only administrators can delete records, other users can't. They can only edit (if they have the right role) as maybe someone else is using them at the same in his/her teaching/learning activities.

File size: there is a limit in size about file to upload (256 MB). It depends on technical needs but also has the task to force users to check the model quality and the amount of data, and learn how to manage them before uploading.

File format: there are some specific file formats that can be uploaded (image, IFC, etc...). For every other type of file (e.g. BIM model, video) a simple compressed archive (.zip o .7z) can be created.

The simplest way to use Unibo OLR DB contents in teaching activities and in BLE website is to link by page URL. Every record in the OLR repository has its own web address (URL), it is just needed to copy and paste the entire address in your teaching activities or in the BLE platform or in any platform and browser (fig. 40).

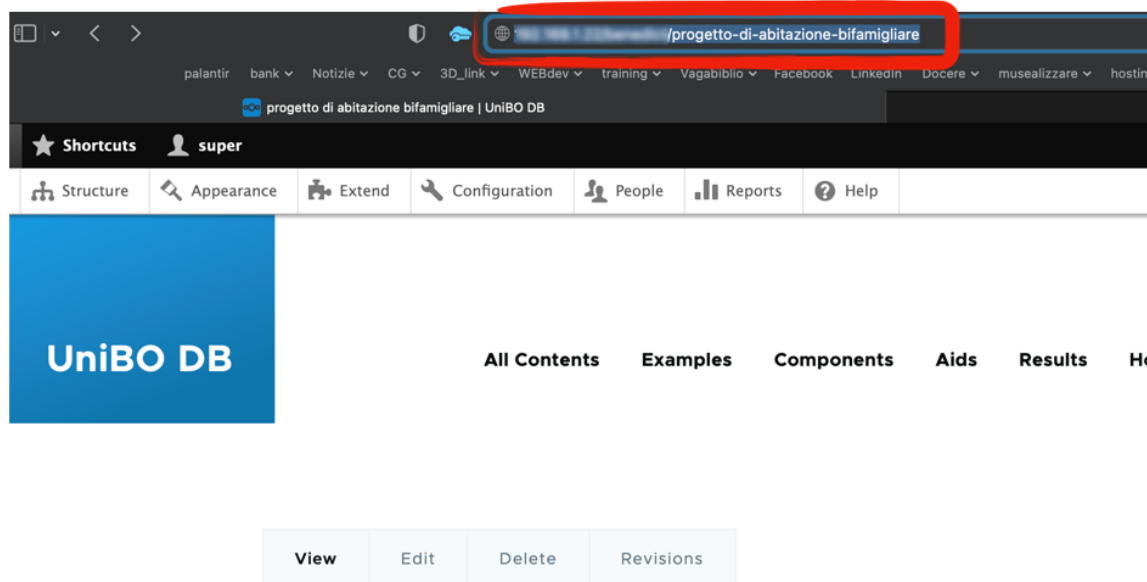


Fig. 40 Unibo OLR DB – link by url.

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The following are screenshots of listing the content / records (fig. 41) and exploring a single record (fig. 42) and syntax searching by URL (fig. 43).

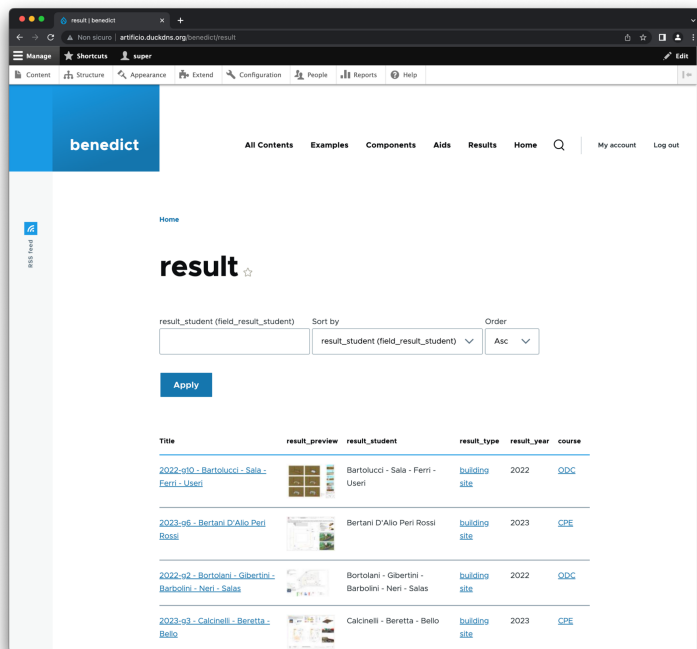


Fig. 41 Unibo DB – listing the records



Fig. 42 Unibo DB – exploring a record

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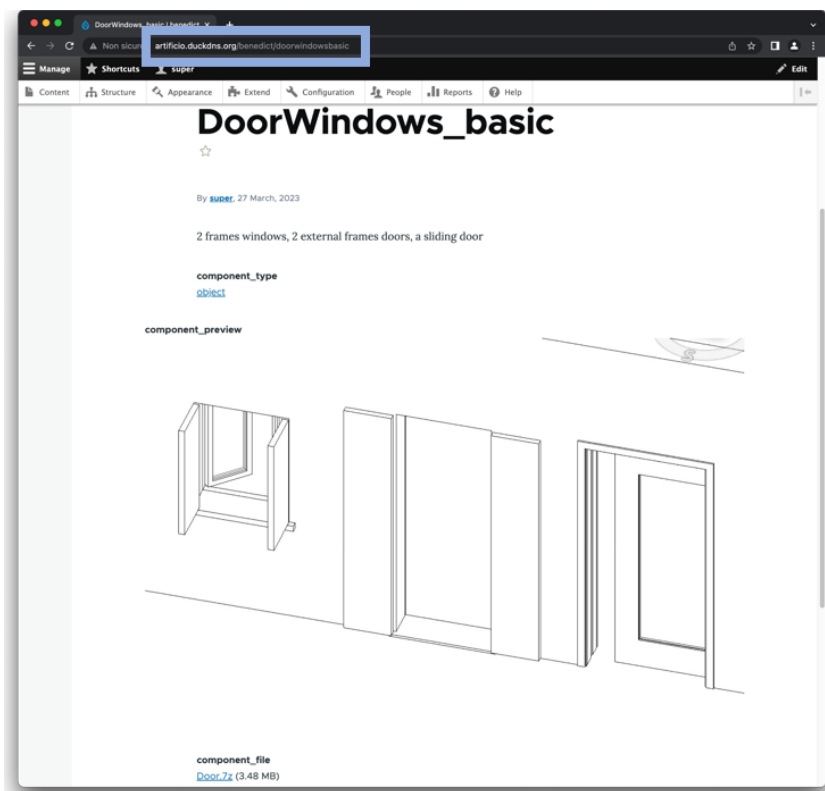


Fig. 43 Unibo DB – link by URL

4 Conclusions

The Open Learning Resources (OLR) repository is intended to provide a database of BIM models and other sources of information that can be used by teachers and learners for BIM-enabled learning activities via the BIM-enabled Learning Environment (BLE) platform. OLR are Open Educational Resources, i.e., learning, teaching and research materials in any format and medium that are publicly available for open access such as text, media, and other digital assets. For BIM-enabled learning, these typically take the form of case studies of buildings / facilities that have been designed and engineered in industry or in the educational environment, for example, in previous courses. Thus, while the BLE platform offers teachers and learners the necessary functionalities to carry out BIM-enabled learning, the OLR repository is the integrated database of learning resources that enables this.

In developing the OLR repository, a central challenge was to establish an effective system of classification to describe (and thus make searchable and accessible) the BIM models, model elements and other materials that constitute the OLR. The possibility to navigate the OLR repository is of critical importance and it depends on data format and BIM object categorization. BIM models can be classified as types of models and model elements. All models are composed of model elements that have properties and attributes, and each different BIM authoring tool, as well as the OpenBIM IFC file format and classification system, has its own unique terminology to describe these components. Due to the complexity of buildings, a sophisticated ontology is required to develop an understanding of how model elements may relate to one another.

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Within the BENEDICT project, the requirements for the OLR repository were identified and analysed before the development of the server and repository commenced. A Beta version of the repository was presented in the E3 validation workshop of March 2023 (in Bologna), and the first online version (<https://giadeit.com>) was presented and accessed by consortium partners in the C1 joint staff training event of June 2023 (in Tallinn). A specific hosting system was developed and, from July 2023, the final version of the OLR repository has been fully online hosted on a Unibo server (with the address <http://ble.unibo.it>).

The Unibo server that hosts the OLR repository was developed for the BENEDICT project and includes includes a Content Management System (CMS) powered by Drupal. The Unibo repository currently has 1 TB of storing space and the hosting is granted for a three-year period.

In the repository the Learning Resources are categorized in four main classes: Examples, Components, Aids, and Results. Examples are fully solved BIM solutions to be used as examples by learners, while components are useful elements for BIM work. Aids are actual projects and BIM documentation and information materials; results are the outputs of students' work in pilot module courses.

The users of the Unibo repository must follow different rules depending on user role. The possible roles are the following: guest accounts – anonymous; and registered accounts. Registered accounts can be learners, teachers and system administrators. Anonymous accounts have some restrictions, they can only view the web site but can not enter the records. Registered accounts must be activated by the system administrator, and then they can upload /download and edit contents.

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