DIGITALISATION OF CONSTRUCTION

DIGITAL SKILLS FOR WORKPLACE MENTORS IN CONSTRUCTION SECTOR APPRENTICESHIPS

(CONDAP Project)

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CONDAP

Co-funded by the Erasmus+ Programme of the European Union

Ingeniería y Tecnología

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PREFACE

Digital Skills for Workplace Mentors in Construction Sector Apprenticeships (CONDAP Project)

The present is characterised by an unprecedented change, known as the Third Industrial Revolution, where new technologies such as renewable energies or digital tools for management and communication are being shaped and where the future professional development must be focused on, to avoid misalignment between job supply and demand. As far as the construction sector is concerned, we could approach the introduction of new technologies from three different aspects: energy efficiency and sustainable construction, digitalisation and organisational, management and communication skills.

On the one hand, the energy efficiency measures required by the institutions are increasingly demanding. According to the Sustainable Development Goals and the European Targets for 2030, energy efficiency must be increased by 35%, greenhouse gas emissions must be reduced by 40% and a renewable energy rate of 35% must be achieved. The new challenge for the building sector is to further expand knowledge and to integrate modern environmental technologies and to implement such energy efficiency measures in them in order to reduce consumption and to become more sustainable with the environment. Globally, buildings consume more than a third of total end-use energy and cause almost a one fifth of total greenhouse gas emissions. Reducing energy use in buildings is a climate change imperative, but it is also a business opportunity.

On the other hand, the construction industry is also rapidly evolving with digital technologies. Recently, the potential of BIM (Building Information Modelling) systems for the efficient management of construction projects is beginning to be exploited. This is a software able of representing the physical and functional properties of a building in such a way that a knowledge resource is obtained in a common technological environment where information is shared and constitutes a reliable basis for decisions during the project life cycle, from the earliest conception until demolition. This kind of tools allows to save many expenses and to speed up processes, so they will be essential in the imminent future and it is important that the trainees of the present are well acquainted with them.

Finally, the importance of management and communication skills at the organisational level must be emphasised. The way information flows in an organisation, across departments, between management colleagues, trainers and trainees is crucial. It is a complex process that takes a long time to build, maintain and continuously improve. Effective communication can make collaboration productive and mutually beneficial, especially for trainers. The use and implementation of digital technologies for communication, as well as social networks and virtual environments can also offer us efficiently the support needed for good communication and management in the field of construction work.

The CONDAP project aims to support the provision of vocational training for trainers in the construction sector by offering a comprehensive modular course that ensures easy and free access to relevant educational material and tools, thus responding to the needs of VET providers and trainees in the sector. After collecting the opinions of different stakeholders within the building and training sector with different surveys and desk researches, the project partners have developed three different thematic units for this purpose:

- LU1: Energy efficiency and sustainable construction
- LU2: Digitisation in construction
- LU3: Organisational, management & communication skills

This book includes the first teaching unit.

The consortium of this project is integrated by five partners from different countries and with different but complementary profiles in order to address the objectives of the project. The different partners come from the vocational training sector, research and the university world. Specifically, the consortium is composed of the following organisations

* INSTRUCTUS (www.instructus.org)- UK

* Vilniaus statybininku rengimo centras (www.vsrc.lt)- Lithuania

* Universitat Politècnica de València (http://www.upv.es/)- Spain

* EXELIA (www.exelia.gr/en) – Greece

* EBC (http://www.ebc-construction.eu/) – Belgium

This work has been possible thanks to the contributions of all the partners who are part of the CONDAP project, as well as the companies and organisations from which some of the contents of this work have been extracted.

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INDEX OF CONTENTS

PREFACE **5**

CHAPTER I: INTRODUCTION **11**

1.1. Project background 13

1.2. Introduction to LU2: Digitalisation of construction 31

CHAPTER II: LEARNING UNIT: DIGITALISATION OF CONSTRUCTION **33**

Lesson 1: Introduction 35

Lesson 2: Building Information Modelling Methodology. Concept and Definitions 40

Lesson 3: Implementation of BIM in a construction Project 50

Lesson 4: Project Management using BIM 54

Lesson 5: Other digital tools used in construction 59

CHAPTER III: CASE STUDIES **63**

CHAPTER IV: EXERCISES **75**

4.1. Multiple choice questions 76

4.2. Short response questions 80

4.3. Frequently Asked Questions 81

4.4. Timed categorization exercises 85

CHAPTER I:

INTRODUCTION

1.1. PROJECT BACKGROUND

In the initial phase of the project, activities were carried out to identify the priorities and needs of trainers in terms of digital skills within the construction industry. To do this, each partner had to bring together a large group of stakeholders from their region or country including construction companies, vocational training providers, construction workers, industry experts, construction software companies, professional associations, students, new workers, etc.

A research was carried out based on three methods:

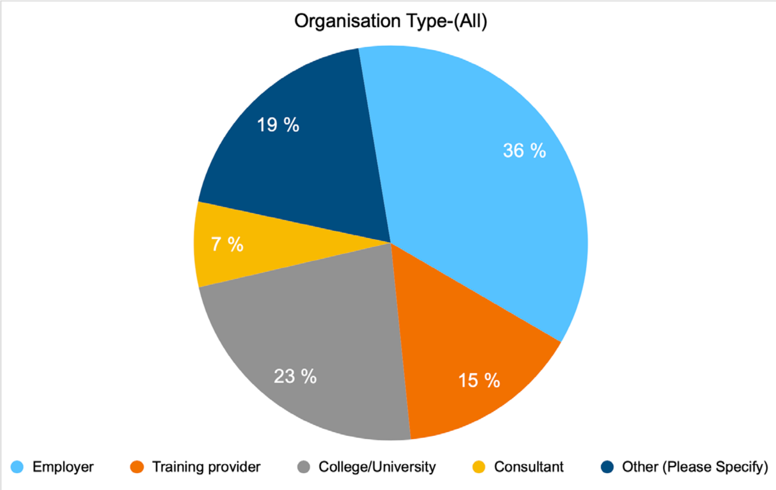
- **Field studies** through online surveys that were distributed among the contacts and stakeholders of each project partner.
- **Semi-structured and individual interviews** with professionals from the construction sector.
- **Office research** carried out by each partner to find out the requirements, needs, technologies, teaching methodologies and new developments in the construction sector and its digital tools.

In the **field studies**, respondents were classified according to the type and size of organisation they belonged to, their job function and their years of experience. The surveys were divided into two parts:

- Part A focused on finding out what the basic digital skills requirements were that building apprentices should have such as handling digital data, searching for information on the Internet, creating documents with office, using electronic media and collaboration, creating websites, using company-specific software, etc.
- Part B aimed to find out the importance given by the surveyors to certain areas within the construction sector such as: digital solutions for sustainable construction and energy efficiency, building information modelling (BIM), virtual and augmented reality, the internet of things, computer aided design, etc. In addition, they were given the opportunity to add those areas not shown that they considered relevant.

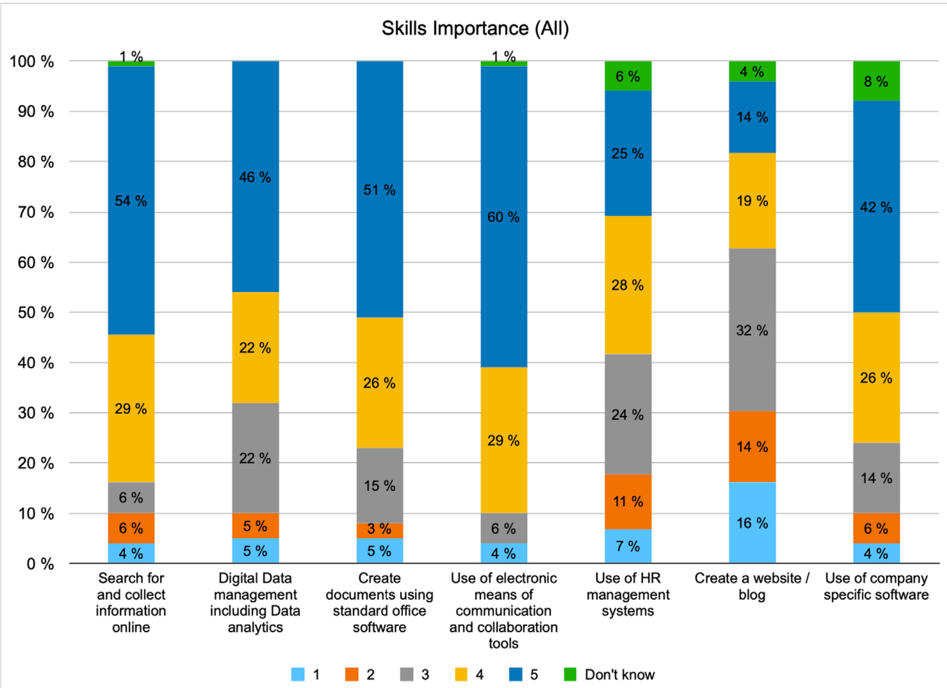
The results of the field studies are shown below:

- Classification of respondents by type of organization



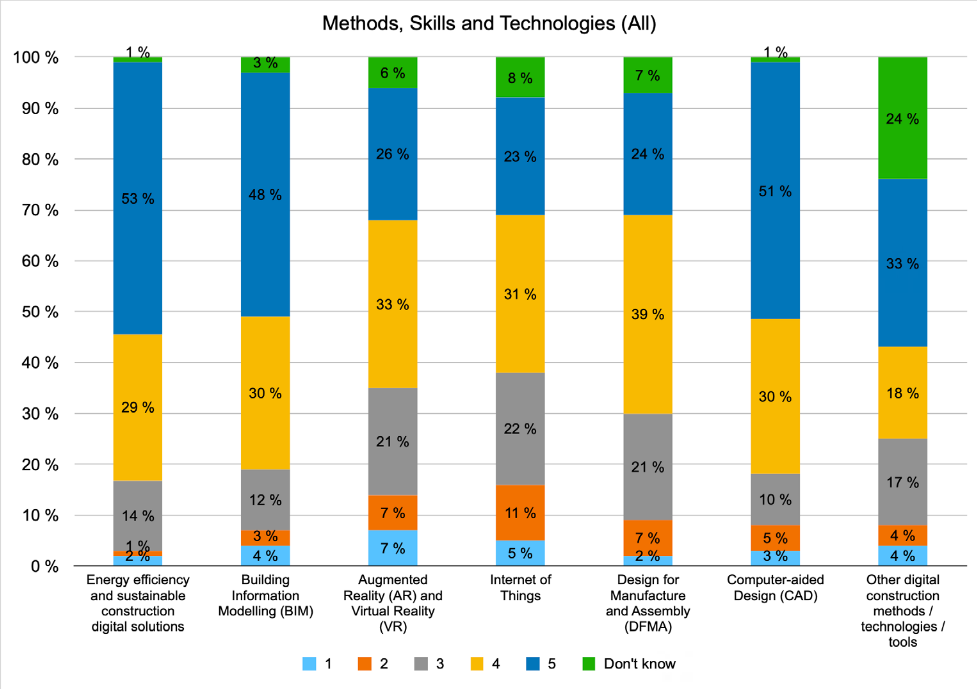
In addition, respondents were almost equally divided in terms of the size of their organisation or company (35% small, 28% medium and 37% large) and 67% of them had more than 10 years experience working in the construction sector.

- Results of part A of the survey:



In addition, respondents stressed the importance of using telecommunication applications such as Skype, ZOOM, MS Teams, Mailbox, etc, virtual collaborative environments for online document sharing such as Google Drive or Dropbox and digital platforms for distance learning such as Webex.

- Results of part B of the survey:



Some of the comments indicated the following additional areas as relevant: artificial intelligence, work safety or the use of drones to avoid working at height.

In conclusion, after analysing the results of the field study, the areas and skills that were most relevant to the respondents were:

- Use of electronic media and digital collaboration tools
- Digital solutions for sustainable construction and energy efficiency
- Building Information Modeling (BIM)
- Computer Aided Design (CAD)
- Search and data collection on the Internet
- Document creation with Office software

The **semi-structured interviews** were conducted to obtain a more in-depth and elaborate view of the skills that are considered most needed by the trainees through a personal interview with one of the stakeholders. In this interview the following questions were asked:

1. What kind of digital skills and tools do you consider important, so that construction managers and apprentice/student coordinators can effectively teach new skills, especially with regard to developments in the construction sector?
2. When you think about the digitisation of the construction sector and digital construction methods, which of the following topics come most to mind?
3. Can you describe the usual/ideal work profile of the training coordinator in construction?
4. What are the main factors that hinder the effectiveness of training schemes in the construction sector, leading to an increase in drop-out rates?
5. Who should be responsible for providing training to trainers of workers and apprentices in the construction sector (Alternative question- What training do you think should be available for coordinators/trainers in the construction industry)?

Regarding the first and second questions, the interviewees highlighted the following skills, tools, methodologies and digital technologies and some of their most relevant aspects:

- Many agreed on the importance of building information modelling (BIM). This is a working method that is defined in the context of the collaborative culture and integrated practice, since it integrates all the agents involved in the building process (architects, engineers, builders, developers, facilities managers, etc.) and establishes a transverse communication flow between them, generating a virtual model that contains all the information related to the building throughout its life cycle, from its initial conception, during its construction and throughout its useful life, until its demolition. The information provided to the BIM model, comes from different types of software, modeling programs, structural calculation, MEP, budgeting software, energy behavior analysis, sensors, etc. The knowledge of all these tools and of the capacity of interoperability between them, is fundamental for the correct implementation of the BIM.
- Some general working software were highlighted, such as:
  - Software for preparing reports or presentations: Word, Excel, PowerPoint, Adobe.
  - Handling of database software: Access, CRM
  - Internal company working tools to communicate and collaborate with the trainees.
- Specific software in areas of:
  - Energy efficiency and certification, sustainable construction, integration

  of renewables
  - Operations management (lean production), remote manufacturing and numerical control machines (CNC)
  - Financial (ACCA) and administrative for the tendering of bids, invoices, tool reports, etc.
  - 2D and 3D digital design (SEMA, Revit, AutoCAD, SolidWorks, WikiHouse).
  - Work safety
  - Circular economy
- Intelligent technologies and automatons
  - Simulation and digital twins to monitor objects or systems and analyse their behaviour in certain situations and improve their effectiveness. An augmented reality and virtual environment tool for simulation is Virtual Reality Headset
  - Smart meters in buildings and the Internet of things
  - Artificial Intelligence
  - Smart Cities
  - Drones to access difficult or dangerous sites, work robots
- Use of the internet for information search, management of websites and blogs and social networks (LinkedIn, Twitter, Facebook), digital marketing.
- Communication tools such as Skype, Messenger, whatsapp, viber.

As for the third question, the qualities and attributes that a trainer should have according to the interviewees are summarized in the following:

- General qualities and attributes:
  - Understanding of the trade and competent use of modern technologies and access to digital training resources and tools.
  - Strengthen the confidence of the new workforce in the industry and convey a sense of reality and effective use of digital tools to address real challenges, such as productivity in industry. Encourage mentors to think differently and beyond their industry, providing a glimpse of what can be achieved using different skill sets and perspectives. Motivation.
  - Practical knowledge of modern building information modelling (BIM) technologies and collaborative approaches to building design and operation; to establish a benchmark and standards for collaborative organisational work. To update the evolution of new technologies in building and to update the knowledge of the trainees.

- Sufficient human psychology to understand the age groups of workers/ learners and to be able to interact effectively with them.
- Make greater use of virtual interaction in tutoring and use remote connection tools to increase forms of communication between trainees and trainers.
- Responsibility, adaptability, management skills, active listening, conflict management and creativity.
- Continuous support to employees in their training for promotion to other job categories.
- Knowledge of the apprentice's job requirements and occupational safety.

- Demands:
  - Frequent tutorials and meetings (face-to-face or remote).
  - Planning with a structured agenda and updates.
  - Advice, evaluation, support and follow-up. Discussion forums with other learners
  - Recorded activities
  - Setting goals and challenges Proposing training activities associated with the learner's daily tasks.
  - Ability to tackle problems.
- Training methodology:
  - 6-step working model process in apprentice training (1) Reporting, (2) Planning, (3) Deciding, (4) Behaviour, (5) Monitoring and (6) Evaluation.
  - Student centred design
  - Application of innovative methods and digital tools for training.
  - Adopting the principle of "less is more" for online learning.
  - Continuous improvement of training by offering courses with innovative digital construction methods and tools.
  - Supply of competences according to demand.

The fourth question sets out the hidden factors which, in their absence, could hamper the effectiveness of training schemes in the construction sector and increase drop-out rates:

- Motivation. Career development or value associated with training.
- Qualified trainers or coordinators in the company who meet the expectations and motivation of the trainees. Training programme for

trainers and workplace support from the company to train trainers and apprentice coordinators. Increased interest of employees in the company to become trainers.

- Consideration of individual circumstances. Flexibility and willingness of employees to learn new things. Age factor, where the use of technologies is a bit reticent.
- Clear vision. Quality of the training offer. Modern and innovative training methodologies suitable for training in digital skills. Consistency in work systems. Technology that has to be suitable for its purpose. Promoting confidence in technology.
- Coherent framework or infrastructure to facilitate the matching of skills supply and demand. A system that facilitates more competency-based and demand-driven curriculum management.
- Clearly defined skills to be integrated into the workplace. Competence that affects innovation and productivity.
- Understanding the industry segment and the size of the company. The construction industry can be quite segmented with little spare capacity. On the other hand, industry has its particularities where most of the workforce is not office-based. Digital infrastructure in the company.
- Culture of collaboration and improvement.
- Adequate financial flows to respond to current challenges. Sufficient state support for companies that take in apprentices.
- The rights and responsibilities of enterprises providing apprenticeship training should be clearly defined in regulatory acts.
- Communication and collaboration with vocational training centres. Research and development, and investment in innovation. Model of functional training, financing and service provision.
- Identification and addressing of gaps and mismatches in existing skills. Providing clear and coherent information management strategies to help find the information to make timely decisions. Assist in interpreting data to influence decision making.
- Establish the appropriate parameters to eliminate errors due to the human factor. Using the right software to avoid technical problems and duplication of effort in data processing that relies on general measurements.
- Accepting change. On average, it takes about 10 years on average to make the change become an implementable process.
- Gender factor. The construction industry has been predominantly male, and must change. Women can play an important role in BIM technology,

they should be widely encouraged and promoted through events, awards events, conferences, networking opportunities.

Finally, the answers to the last question about what training there should be for coordinators/trainers in the construction industry and who should provide it, are summarised in the following:

- Companies / businesses (in-company training)
  - Own company assisted by individual experts or training centres. Large companies provide these courses themselves, with the help of their human resources departments.
  - Specialised courses for VET coordinators/trainers at state level.
  - Many employers believe that, instead of a formal pedagogical qualification, trainers should know the processes of the industry and the company and be able to explain them to the trainees and instruct them in their tasks. Instructing trainees is no different from instructing any other new employee and is part of the daily practice of many of their employees.
  - In SMEs trainers are mostly self-taught or learn from their colleagues.
  - Encourage trainers to attend short courses or visits provided by companies.
- Vocational training centres:
  - Specialized training centres in construction.
  - Training associations.
  - Company employees are often unable and/or unwilling to train others due to workload, confidentiality issues, risk of possible damage to equipment or fear of possible future competition. The main reason why companies cooperate with VET providers to deliver apprenticeship training is to get the qualified workers they need and the possibility to promote themselves as potential employers.
- Online courses:
  - Short, specific online courses so that trainers have the flexibility to do so.
  - Mass open courses online (MOOCs) and open education resources.
- Initiatives financed by national and European projects:
  - Specific train-the-trainer programmes should be developed to offer short courses for VET teachers with the specific focus on digitisation.
  - Flexibility and prompt reaction in the provision of VET services to changes in the industry is required, including the opportunity to develop new training programmes/modules for high-demand occupations or for new

emerging occupations.

- Courses on pedagogical and psychological aspects are available from national teacher training institutes.

- Professional development:
  - Opportunities for continued professional development.
  - The support of a trainer should also depend on the level of training. For example, EQF level 4 may be advised by a chartered engineer or professional association member who will be able to assess basic skills and competencies.
  - Attendance at training events and seminars.

With regard to desk-based research, this was carried out as a complementary method of gathering information on the digital skills needs of trainers in the workplace and reviewed the availability and content of reports, existing courses and other documents and information sources that each partner could access about:

- Digital skills needed for apprentice trainers and complementary digital skills for construction workers.
- Construction methods, skills and digital technologies
- The role of trainers in the workplace and in the company who participate in the learning, to draw conclusions about the needs of work based learning.
- Existing train-the-trainer courses, focusing on digital skills and construction methods.
- Existing training courses on digital skills and construction methods.
- Skills gaps and deficiencies in the construction sector (also by reviewing information on the management of learning plans)
- Ways in which work-based learning can support the change in skills needed to modernise learning.

The results of the desk research were expected to reveal trends in the construction industry and the need for digital construction knowledge and methods, and therefore to highlight findings on how mentor training can support the change of knowledge needed to apply digital methods and technologies in the context of construction learning.

Each partner contributed evidence from their countries by providing at least 5 sources of information (25 in total from all partners). The answers obtained allowed to know the context in which each country is in the digital field in the construction sector.

The final report analysed the three types of research methods in terms of content and set objectives in relation to the real benefits received. Although the number of responses to the questionnaire is below the target of 150, the rest of the research provides complementary coverage through interviews and desk research. The total of all expected responses was 190, including surveys, interviews and desk-based research, providing good study and information on the courses taken in the different countries and the most developed topics.

With regard to the **field studies**, in particular the answers obtained in the survey, the following graph shows per partner which results were obtained (orange line) compared to the expected ones (blue line). VSRC and the UPV achieved a higher number of responses than the target, therefore obtaining a greater representation of responses from stakeholders and staff associated with the construction.

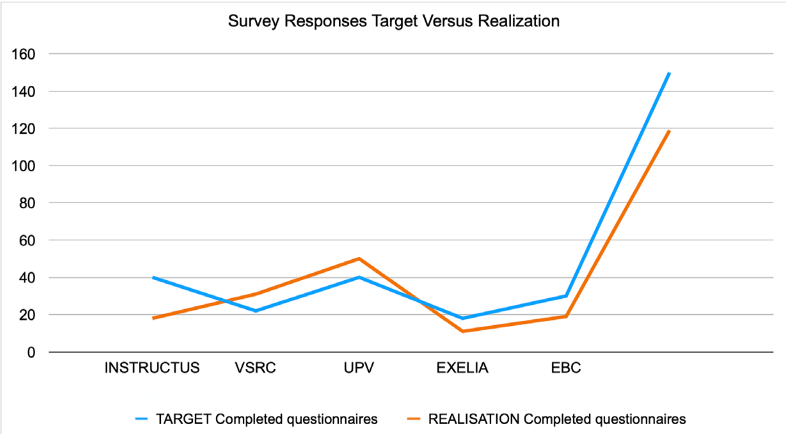


Chart 1. Survey: responses obtained and expected per partner

On the other hand, **semi-structured interviews** are a very effective method of obtaining first-hand information, whose time investment makes it difficult to obtain a large number of them. However, INSTRUCTUS and EBC obtained more responses than the target value, thus counteracting the lack of information with respect to the field studies.

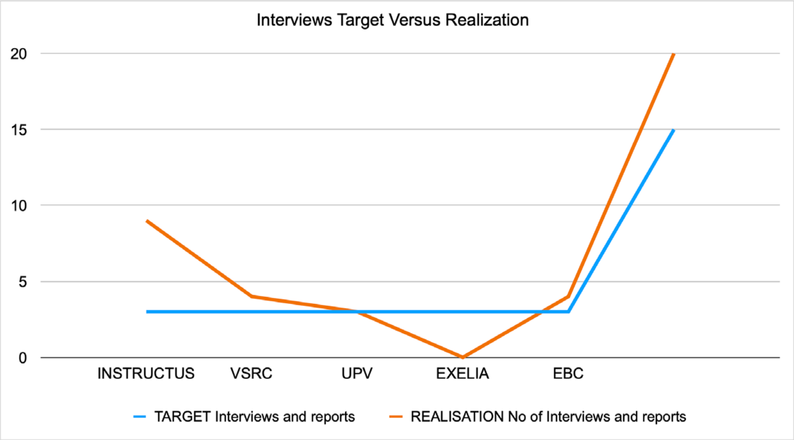


Chart 2. Semi-structured interviews: responses obtained and expected per partner

The last of the methods is **desk research**, through which sufficient information was obtained to complete any data that might be missing from the field studies and semi-structured interviews. We are making known the requirements, needs, technologies, teaching methodologies and new developments in the construction sector and its digital tools in each country. All partners reached the target value and even exceeded the set values. This method had a very good response and usefulness.

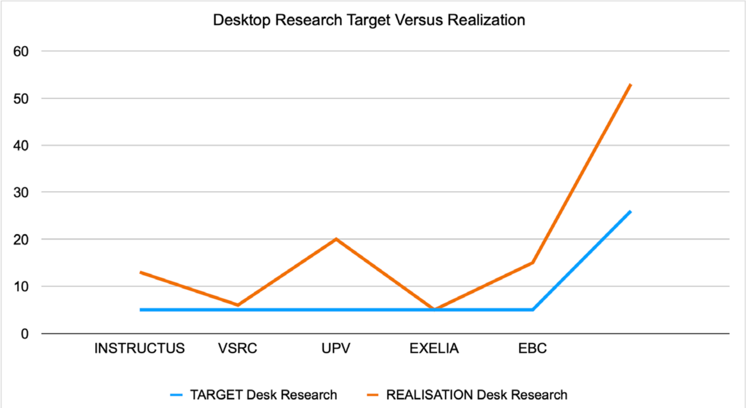


Chart 3. Desk research: responses obtained and expected per partner

In conclusion, the following graph shows the different methods (questionnaires, interviews and reports and desk research) comparing the objective value with the number of responses obtained. As can be seen, the overall number of responses is very high, so the results obtained are well contrasted and there is variety thanks to the response of the different partners.

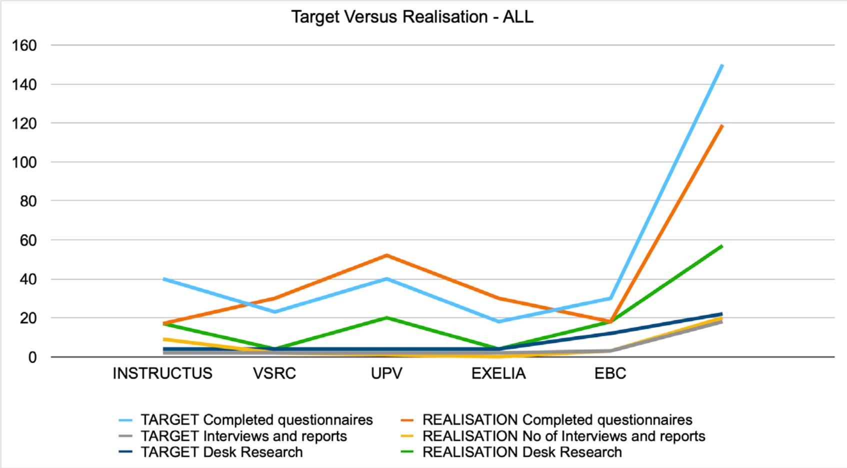


Chart 4. Research methods: answers and target values per partner

As a result of these three types of research conducted by partners in five countries, the following learning objectives were reached which should define the content of the CONDAP course:

- O1. Understand and apply new technologies and software for digital construction
- O2. Share data and construction models using integrated digital systems.
- O3. Develop the skills and knowledge necessary for trainers in the application of digital construction methodologies.
- O4. Develop the skills and knowledge necessary to train students in knowledge management systems and advances in digital technologies.
- O5. To develop the knowledge and understanding to define a customised methodology to support students in their development and improvement in the use of digital tools/technologies.
- O6. Develop immersive learning tools and training in digital construction relevant to your company for use by students.
- O7. Develop methodologies to explore and overcome barriers for the use of digital advances in construction.

Once the research has been completed, the second milestone of the CONDAP project is reached, which aims to define the structure of a curriculum with pedagogical guidelines for trainers and VET providers, in order to train them in digital construction methods. To this end, three activities have been carried out based on the results of the research. The first of these consists of grouping the learning objectives together with the knowledge areas that proved to be the most interesting for the respondents, extracting from this some learning outcomes that will later form the teaching units of the CONDAP project, which are presented in this compendium.

Firstly, it is important to define the system in which the teaching units will be framed, known as the European Credit Transfer System for Vocational Education and Training (ECVET). This is a common methodological framework that facilitates the recognition and transfer of learning credits from one qualification system to another within the European Education System. ECVET works in partnership with the European Qualifications Framework (EQF) to provide greater transparency in European qualifications, promoting worker and student mobility and facilitating learning. In particular, the implementation of ECVET requires that qualifications are described in terms of learning outcomes; that units are formed from the learning outcomes; and that units are often grouped together to form the basis of qualifications.

The CONDAP project is thus in line with this procedure, respecting the ECVET procedure, defining learning outcomes and forming learning units from these. It is important to clarify that the processes of assessment, validation and recognition must also be agreed between all participants and must respect existing national, regional, sectoral or institutional practices. This initiative makes it easier for European Union (EU) citizens to have their education, skills and knowledge recognised in an EU country other than their own. ECVET complements the European Credit Transfer and Accumulation System (ECTS) by establishing a link between Vocational Education and Training and Higher Education.

According to the ECVET system, a learning or teaching unit is a training element that responds to a set of learning outcomes, defined in terms of knowledge, skills and competences that can be assessed, validated and certified. Through the analysis carried out in the CONDAP project, explained above, learning units based on learning outcomes resulted as shown in the following figure:

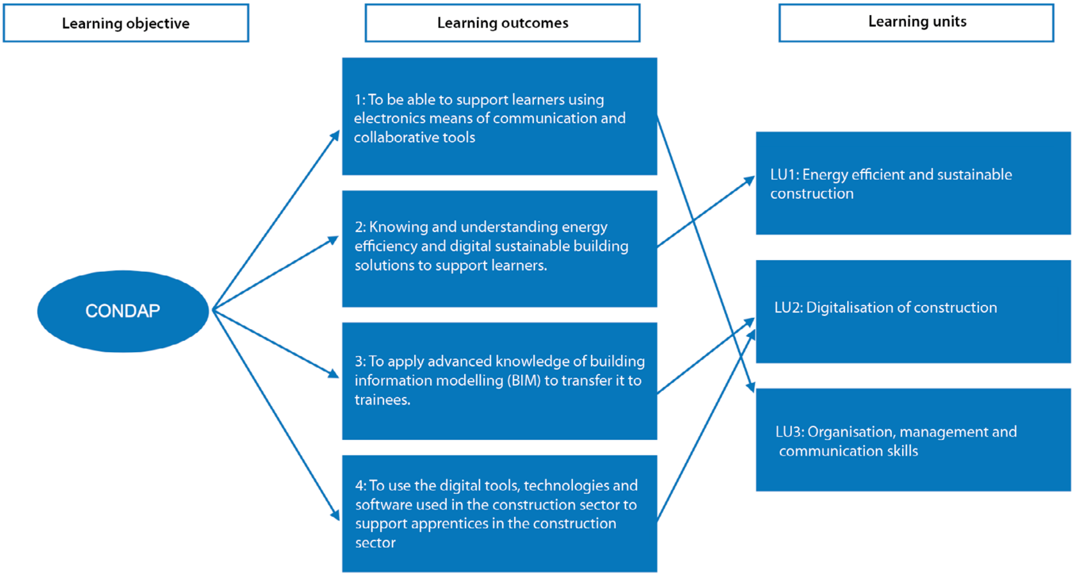


Figure 1. Grouping of learning outcomes CONDAP.

Finally, the teaching units to be carried out in the CONDAP project obtained from the learning outcomes, as illustrated above, are:

- LU 1: **Energy efficient and sustainable construction**; which mainly responds to learning outcome 2: "Knowing and understanding energy efficiency and digital sustainable construction solutions to support learners".
- LU 2: **Digitisation in Construction**; related to learning outcome 3: "Apply advanced knowledge of Building Information Modelling (BIM) to transfer it to trainees" and learning outcome 4: "Use digital tools, technologies and software used in the construction sector to support trainees in the construction sector".
- LU 3: **Organisational, managerial and communication skills**; corresponds to learning outcome 1: "To be able to support learners using electronic communication and collaboration tools".

On the other hand, the teaching units must also meet a number of requirements, suggested by European principles:

- Units of learning outcomes can be completed and assessed independently of other units of learning outcomes.
- They are structured in such a way that relevant learning outcomes can be achieved in a specific time interval. Therefore they should not be too long.
- They include all the learning outcomes necessary to meet the objectives of

the units and are designed to be assessable.

The second activity within the second intellectual output of CONDAP consists of defining the specifications of the teaching units. That is, the scope and essential requirements that the corresponding training programme must meet. The training course material will be developed on the basis of the definition of the course specifications.

The specifications of the learning units are based on the ECVET principles, which indicate that each unit can include the following elements, which will allow the units to be accepted within the ECVET framework.

- EQF qualification level
- Recommended prior knowledge
- Duration of the learning process
- Comparative weighting of learning units
- Allocation of appropriations
- Prerequisites for attending each learning unit
- Training content
- Evaluation methods

The duration of the courses is also specified, according to the accumulated hours in the following categories:

- **Teaching hours:** contact hours between the instructor and the student in the course plan, including conferences, tutorials, seminars, workshops and lab-practice sessions.
- **Self-study hours:** the study of something by oneself without direct supervision or class attendance.
- **On-site hours:** study visits that can be organised jointly or carried out individually.
- **Assessment hours:** the time needed to prepare a piece of work, including time allocated to the exam (if any).

The learning hours of each teaching unit have been assigned according to the results obtained in the analysis of the first intellectual result (O1). The most requested topics were "Energy efficiency and sustainable construction" and "BIM and other digital construction methods". Therefore, each of these topics represents 40% of the course dedication, while learning unit 3 "Organisational, management and communication skills" represents 20% of the weight of the whole course.

Therefore, the CONDAP course involves the following hours for each learning unit:

- **LU 1:** 12 hours of lessons, 3 hours on site, 3 hours of self-study, 2 hours of evaluation.
- **LU 2:** 10 teaching hours, 5 hours on-site, 3 hours self-study, 2 hours evaluation.
- **LU 3:** 5 teaching hours, 2 hours on-site, 2 hours self-study, 1 hour evaluation.

In total the course will include the following learning hours associated with each teaching unit in order to define the duration of the entire course:

- 27 teaching hours, plus 3 hours on site in teaching unit 1 and 7 practical hours required for the practical sessions in units 2 and 3.
- 8 hours of self-learning for the trainees for the teaching materials.
- 5 hours of evaluation.

The course will have a total duration of 50 hours distributed in each teaching unit. It is true that the duration of each teaching unit should not be considered as strictly defined, but as a recommended indicator so that integration with existing vocational training courses can be flexible.

As far as the weighting and the allocation of credits are concerned, as mentioned above, the CONDAP course is based on the ECVET system. ECVET credits are a numerical representation of the overall weight of learning outcomes in a qualification and the relative weight of units in relation to the qualification. In this way, they allow for the framing of assessed skills between partners, trying to facilitate the transfer of learning outcomes from one qualification system to another. It is not intended to replace national qualification systems, but to achieve better comparability and compatibility between them; it facilitates the recognition of training, skills and knowledge among European Union (EU) citizens.

The suggested weighting and allocation of ECVET credits for the CONDAP course, taking into account that 10 hours correspond to 1 credit, is as follows:

- LU 1: 40% corresponds to 2 credits.
- LU 2: 40% corresponds to 2 credits.
- LU 3: 20% corresponds to 1 credit.

The total course is 50 hours long, which means 5 ECTS credits.

Finally, for the evaluation of the teaching units different evaluation methods will be used such as open answer questions, multiple choice questions or case study analysis.

Below is a brief introduction to Teaching Unit 1, which will be further developed by including all the necessary material to complement the study and its assessment.

LU2: DIGITALISATION OF CONSTRUCTION

The introduction of digital technologies in the different sectors of society has allowed an increasingly faster development, and this is also true for the construction industry where the use of virtual models is gradually being promoted. In this sector, digitisation stands out, whose conceptual foundations within Building Information Modelling (BIM) systems are attributed to the first computers. BIM technology allows all professionals involved in the project to contribute data and information to a single shared model. By managing all the necessary information and resources of a construction project, it represents a reliable basis for making important decisions during the offer, execution, or maintenance of the building.

The main aim of this learning unit is to introduce the student to the digitalisation of construction, specifically to the Building Information Modelling (BIM) methodology and to project management using digital tools. The unit aims to provide students with an understanding of the foundations and basics of the BIM system, including the relevant software and digital tools.

The unit begins with an introduction to Building Information Modelling, describing the concept, providing the relevant definitions along with the benefits of BIM use in the construction industry. The learning material describes the BIM construction life cycle and maturity levels in detail.

Throughout the unit you will learn about its application and how it is used in project management, including future perspectives. The final lesson of this unit deals with other digital tools used in the construction industry. The learning unit consists of five lessons with theoretical content and key points at the end of each lesson to reinforce knowledge and skills.

Learning outcomes

Learning Unit 2: Digitalisation of construction	
Learning outcome 1	Interpreting and defining the BIM system, including the level of development and the BIM software
Learning outcome 2	To study in more detail the BIM, its main characteristics, and the relevant stages of the life cycle.
Learning outcome 3	Analyse the principles of BIM implementation by delving into 3D, 4D, 5D, 6D, etc. The lesson summarizes how BIM is used in the construction industry.
Learning outcome 4	Address the importance of the BIM in the overall management of the project, from the implementation plan to the future perspectives of the construction industry.
Learning outcome 5	Digitisation and the use of other tools to amplify the use of BIM

Summary of the lessons of the learning unit

Lesson 1. Introduction

This lesson gives interpretations and definitions of BIM, including level of development and BIM software.

Lesson 2. Building Information Modelling Methodology. Concept and definitions

This lesson goes into more detail about BIM, its main features and relevant life cycle stages. The lesson covers essentials about each level of BIM.

Lesson 3. Implementation of BIM in a construction project

This lesson analyses the principles of BIM implementation by going into depth about 3D, 4D, 5D, 6d etc. The lesson summarises how BIM is used in construction industry.

Lesson 4. Project Management using BIM

The content of this lesson addresses the importance of BIM in overall project management from execution plan to future prospects of construction industry.

Lesson 5. Other digital tools used in construction

This lesson gives a wider overview of digitalisation, specifically about other tools to amplify the use of BIM.

CHAPTER II:

LEARNING UNIT: DIGITALISATION OF CONSTRUCTION

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CONDAP

DIGITALISATION OF CONSTRUCTION

CONDAP OPEN EDUCATIONAL RESOURCES

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WHAT YOU CAN EXPECT TO LEARN FROM THIS UNIT

This learning unit introduces the learner into digitalization of construction - Building Information Modelling methodology and project management using digital tools.

The learning unit is divided into five lessons:

- ✓ Lesson 1. Introduction - This lesson introduces learner to the what Building Information Modelling is and its history.
- ✓ Lesson 2. Building Information Modelling Methodology. Concept and Definitions. - This lesson introduces learner to how BIM works and show levels of it. At the end learner will be introduced to the benefits of BIM.
- ✓ Lesson 3. Implementation of BIM in a construction - This lesson introduces learner to how BIM works in a construction and what software is used.
- ✓ Lesson 4. Project Management using BIM - This lesson introduces into how BIM technologies can be used in projects management.
- ✓ Lesson 5. Other digital tools used in construction - This lesson gives learner an opportunity to know what tools, used in construction everyday can be connected to BIM technology.

INDEX

Lesson 1. Introduction

Lesson 2. Building Information Modelling Methodology. Concept and Definitions.

Lesson 3. Implementation of BIM in a construction

Lesson 4. Project Management using BIM

Lesson 5. Other digital tools used in construction

3

LESSON 1

Introduction

Purpose of this lesson is to introduce You to the world of Building Information Modelling and to give You better understanding what it is, to know brief history of it and software used.

INTRODUCTION

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The term Building Information Modelling (BIM) has many interpretations and definitions.

BIM is the acronym for Building Information Modelling or Building Information Model became over time Building Information Management.

The different meanings of the same acronym is due to the fact that the applications of BIM have evolved over time and that the potential of BIM was wider than initially foreseen.

INTRODUCTION

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- Building information modeling (BIM) is a process supported by various tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places.
- Building information models (BIMs) are files (often but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged or networked to support decision-making regarding a built asset.

https://en.wikipedia.org/wiki/Building_information_modeling

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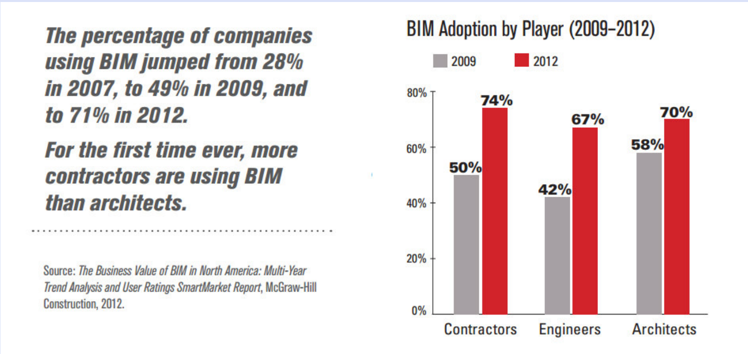
CONDAP

INTRODUCTION

The business value of BIM is significant. The benefits of an architectural design model tied to a relational database have proven to be incredibly valuable:



7

INTRODUCTION

- BIM software must be capable of representing both the physical and intrinsic properties of a building as an object-oriented model tied to a database . In addition most BIM software now features rendering engines, an optimized feature specific taxonomy and a programming environment to create model components.
- A Building Information Model could be designed in a software that is not strictly speaking, „parametric" and where all information and geometry is explicitly defined but this would be cumbersome.

https://www.archdaily.com/302490/a-brief-history-of-bim#

BRIEF HISTORY OF BIM

The construction industry has been going through digitalization for several decades to improve the delivery of built assets:

https://www.archdaily.com/302490/a-brief-history-of-bim#

- 1962
  - Douglas C. Englebart gives us an uncanny vision in his paper *Augmenting Human Intellect*.
  - Herbert Simon, Nicholas Negroponte and Ian McHarg who was developing a parallel track with Geographic Information Systems (GIS)
- 1963
  - SAGE graphical interface and Ivan Sutherland's Sketchpad program
- 1970s
  - Constructive solid geometry (CSG) and boundary representation (BREP).
  - The development various contraptions in the early days of human-computer interaction (HCI)
- 1974
  - One of the first projects to successfully create a building database was the Building Description System (BDS)
- 1982
  - ArchiCAD developed in 1982 in Budapest, Hungary by Gábor Bojár
- 1993
  - prominent example of a simulation tool that gave feedback and 'suggested' solutions based on a model is the Building Design Advisor, developed at Lawrence Berkeley National Lab.
- 2000
  - Charles River Software in Cambridge, MA company had developed a program called 'Revit'.
- 2002
  - Autodesk purchased the company and began to heavily promote the software in competition with its own object-based software 'Architectural Desktop'
- 2008
  - Patrick Schumacher has coined the movement of parametric building models in architecture.

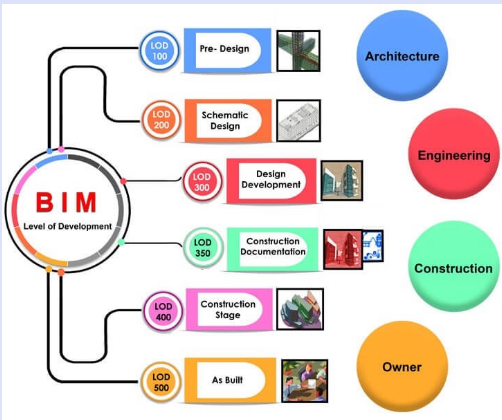
9

BIM LEVEL OF DEVELOPMENT (LOD)

LOD built for various stages of design, 3D visualization, construction-caliber quantities, scheduling, estimations, on-site production control and fabrication.

The BIM's Level of Detail (LOD) defines how the 3D geometry of the building model can achieve different levels of refinement, is used as a measure of the service level required.

https://www.srinsofttech.com/

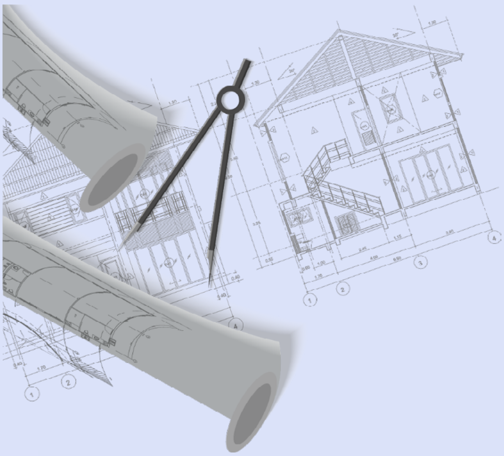


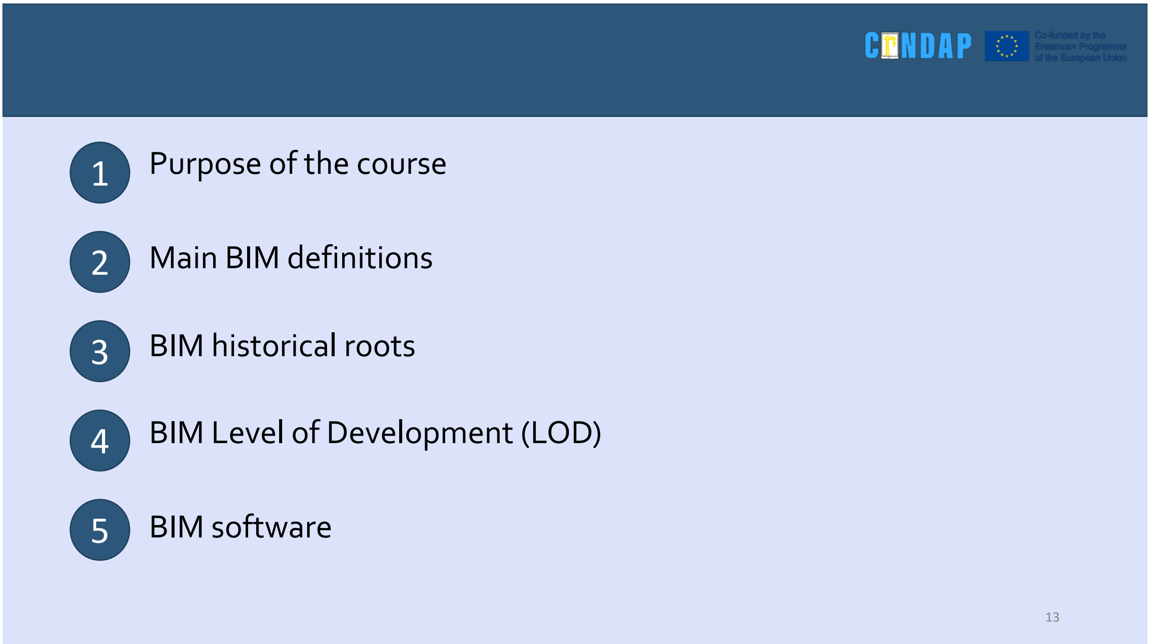
BIM SOFTWARE

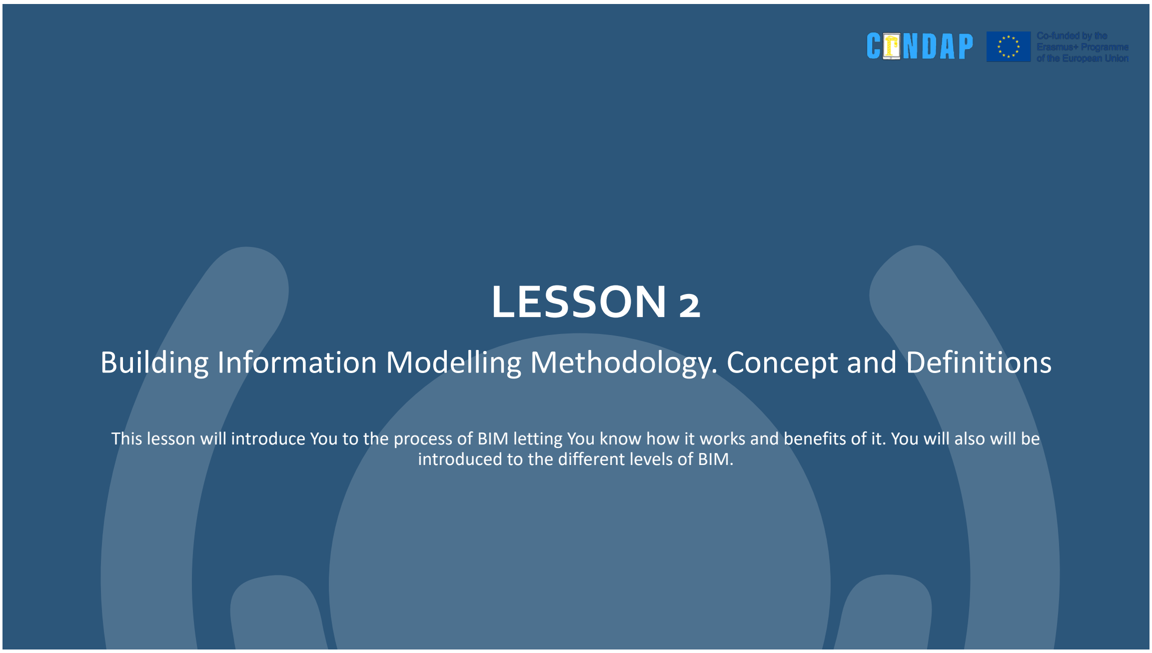
The first software tools developed in the late 1970s and early 1980s, and included workstation products such as Chuck Eastman's Building Description System and GLIDE, RUCAPS, Sonata, Reflex and Gable 4D Series. ArchiCAD's Radar CH, released in 1984 was the first modelling software made available on a personal computer.

Some companies have developed software designed specifically to work in a BIM framework.

Non-proprietary or openBIM standards. BIM is often associated with Industry Foundation Classes (IFCs). IFCs have been developed by buildingSMART, as a neutral, non-proprietary or open standard for sharing BIM data among different software applications.




1 Purpose of the course
2 Main BIM definitions
3 BIM historical roots
4 BIM Level of Development (LOD)
5 BIM software
13


LESSON 2
Building Information Modelling Methodology. Concept and Definitions
This lesson will introduce You to the process of BIM letting You know how it works and benefits of it. You will also will be introduced to the different levels of BIM.

DEFINITION

The official definition of Building Information Modeling (BIM) :

Building Information Modelling is digital representation of physical and functional characteristics of a facility creating a shared knowledge resource for information about it and forming a reliable basis for decisions during its life cycle, from earliest conception to demolition.

National Institute of Building Sciences,

National Building Information Modeling Standard TM (NBIMS), 2008

15

CONCEPT OF BIM

The management of all information, in its entirety, concerning the different phases of the life cycle of a building, from architectural design to post-occupancy maintenance, can be supported on a single common technological environment.

This concept is the basis of Building Information Modeling (BIM) technology.

ALCI´NIA Z. SAMPAIO. The Introduction of the BIM Concept in

Civil Engineering Curriculum. International Journal of Engineering Education Vol. 31, No. 1(B), pp. 302–315, 2015

16

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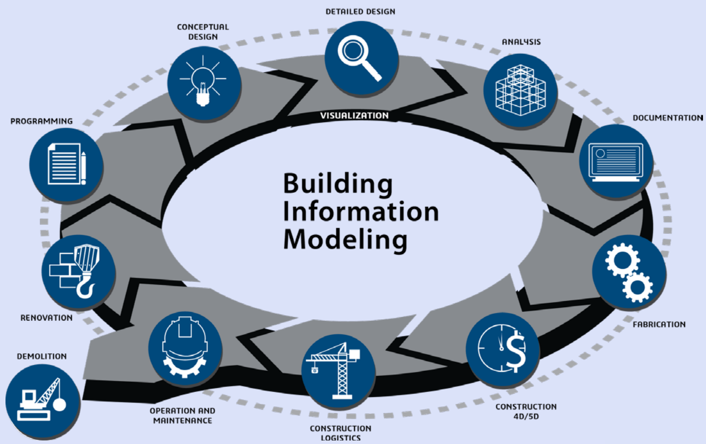
BUILDING LIFE CYCLE IN BIM



BIM is an integrated workflow built on coordinated, reliable information about project from design through construction and into operations.

https://www.cleanpng.com/free/bim.html

17

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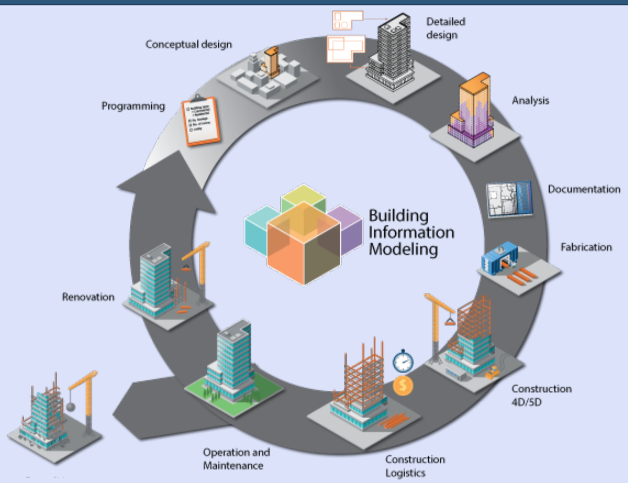
BUILDING LIFE CYCLE IN BIM

BIM let to organize BIM process:

- Programming
- Conceptual design
- Detailed design
- Analysis
- Documentation
- Fabrication
- Construction 4D/5D
- Logistic
- Operation and maintenance
- Renovation or demolition



https://www.cleanpng.com/free/bim.html

18

BIM: FEATURES AND BENEFITS

Modelling not Drawing or Drafting
- Increasing accuracy and efficiency in the design, construction and operation processes

Object Based modelling
- Data base of semantically-rich building objects and properties and Computability: cost estimation, energy consumption, etc.

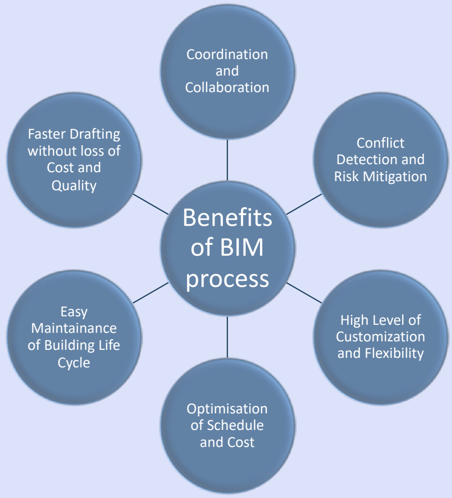
3D Modeling
- Design Vizualization and Generating 2D documents

Parametric modeling engines
- Design intent and options: quick, interactive, different design phases

BIM BENEFITS

75% of companies that have adopted BIM reported positive returns on their investment with shorter project life cycles and savings on paperwork and material costs.

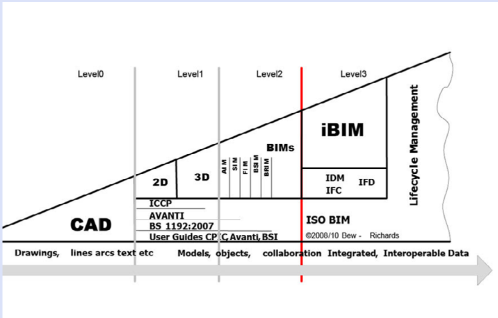
Image courtesy of BluEnt



20

BIM MATURITY LEVELS

The UK maturity model - also known as the iBIM model (the name of its highest level) or the BIM Wedge (due to its famous shape) - was developed by Mark Bew and Mervyn Richards in 2008.

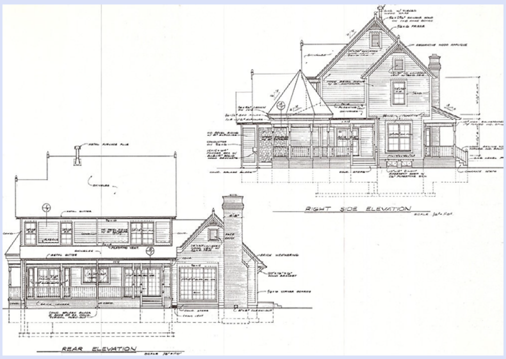


LEVEL 0 BIM

The range of levels that this form of modelling can take are described as 'maturity levels' and are described bon next slides:

Level 0 BIM

Unmanaged computer aided design (CAD) including 2D drawings, and text with the paper-based or electronic exchange of information but without common standards and processes. Essentially this is a digital drawing board.



LEVEL 1 BIM

- **Level 1 BIM**

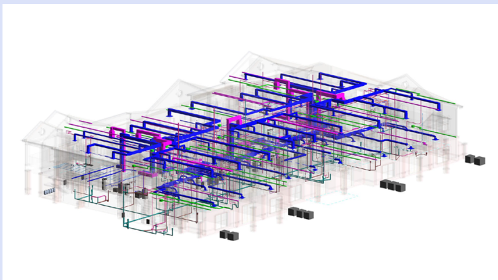
2D and 3D models. A Common Data Environment (CDE) is used in this case.

A CDE is an online shared repository where all the data of the project are collected and managed.

BIM level 1 focuses on the transition from CAD information to 2D and 3D one.

LEVEL 2 BIM

Managed 3D environment with data attached, but created in separate discipline-based models. These separate models are assembled to form a federated model but do not lose their identity or integrity. Data may include construction sequencing (4D) and cost (5D) information.



LEVEL 3 BIM

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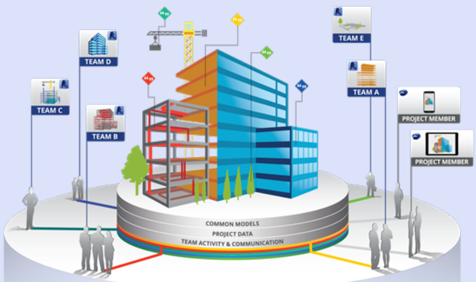
A single collaborative, online, project model with construction sequencing (4D), cost (5D) and project life-cycle information (6D). This is sometimes referred to as 'iBIM' (integrated BIM) and is intended to deliver better business outcomes.

https://thebimhub.com/



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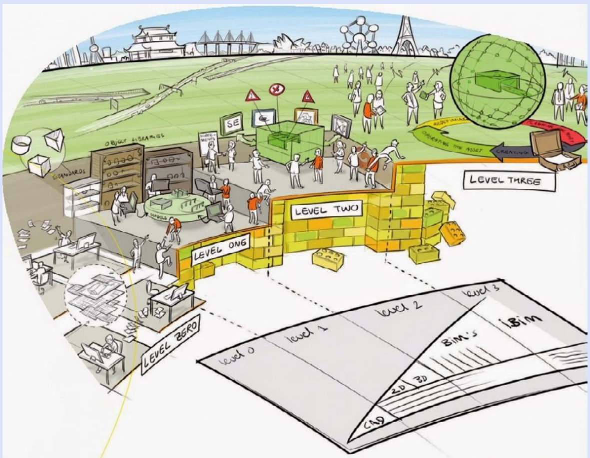
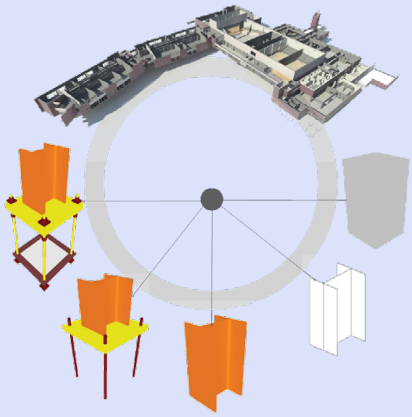


26

LEVELS OF DEVELOPMENT (LOD)

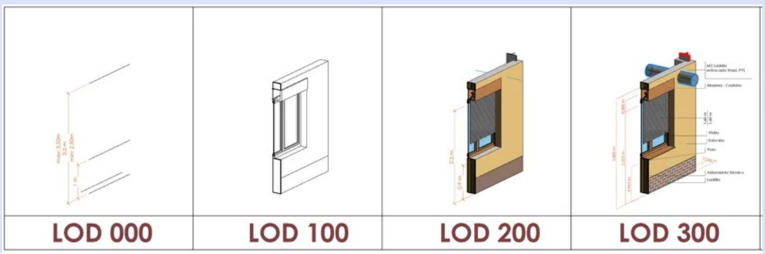
The Level of Development (LOD) specification is a reference that enables practitioners in the AEC Industry to specify and articulate with a high level of clarity the content and reliability of Building Information Models (BIMs) at various stages in the design and construction process.

https://bimforum.org/lod/



LEVELS OF DEVELOPMENT (LOD)

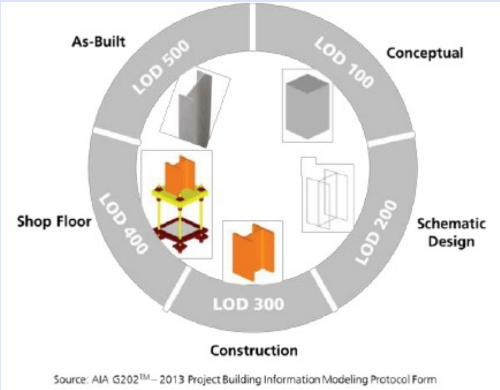
How accurate, or how definitive, the model elements you are connecting to in the model are? Was developed the concept call "**Level of Detail**". A measure of how definitive an element is in terms of costing it.



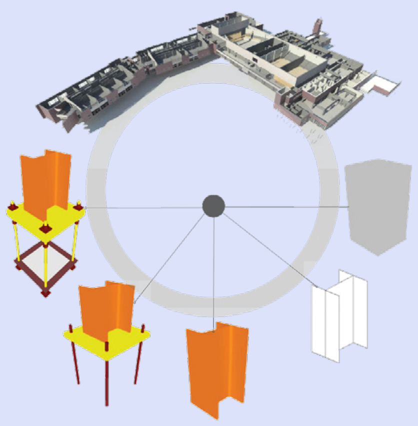
28

LOD OR LOD?

The AIA (American Institute of Architects) decided that this system would be a good one to apply to all uses of a BIM model, from energy analysis to 5D programming. They sensibly renamed it "**Level of Development**" because "**Level of Detail**" could get confused with the amount of information, rather than the decisiveness of the information. Although both still have an acronym of LOD so the two continue get confused (more on that later).



LOD



LOD, as in "Level of Development", is a measure of how seriously you take the information represented by a BIM element. It is not necessarily a measure of the *amount* of information, although obviously there must be enough information to satisfy the LOD level it is at. It is also not a measure of the amount or accuracy of *graphical* information.

The appearance of a BIM element is only one piece of information about that object, and usually the least important. A contractor doesn't need to know what a desk looks like to order it, nor to place it in the building. But they do need to know what the manufacturer and model number is.

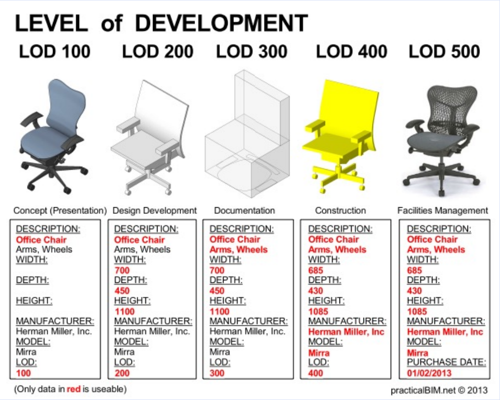
Others may need to know its dimensions to coordinate with things around it, but they too do not necessarily need to know what it exactly looks like.

LOD LEVELS

Therefore LOD levels for a chair might go:

LOD 100 = there is a chair
LOD 200 = there is a chair that has nominal space requirement of 500x500
LOD 300 = there is a chair with arm rests and wheels
LOD 400 = manufacturer and model number.
LOD 500 = manufacturer and model number, supplier, date purchased

or in general terms:
LOD 100 = there is a thing
LOD 200 = there is a thing about this size
LOD 300 = there is a thing with these functions and options
LOD 400 = it is this particular thing.
LOD 500 = this particular thing provided by this person on this date.



ADDED VALUE OF BIM

- Provide support for the project's decision making process
- Parties have a clear understanding of the project objectives and interfaces with other related trades
- Visualize design solutions
- Assist in design and the coordination of designs
- Increase and secure the quality of the building process and the final product
- Make the process during construction more effective and efficient
- Improve safety during construction and throughout the building's lifecycle
- Support the cost and lifecycle analysis of the project
- Support the transfer of project data into data management software during operation

1. Definition of BIM
2. Concept of BIM
3. BUILDING LIFE CYCLE in BIM
4. Bim maturity levels
5. LOD and LOD levels

33

LESSON 3

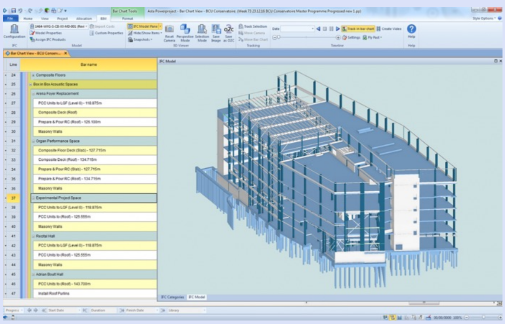
Implementation of BIM in a construction

In this lesson You will be introduced to the how BIM technologies can be usefully used in construction and introduced to the most popular software.

IMPLEMENTATION OF BIM IN A CONSTRUCTION

- Major advantages of BIM are improved scheduling, improved drawing coordinated, controlling time and cost and singe detailed model.
- Enhanced collaboration, requires coordinated drawing, interoperability are the major disadvantages and limitations of BIM.
- Major barriers to low level of BIM implementation are lack of competent staff to operate the software, unawareness of the technology and non availability of parametric library.
- 4d, 5d, 6d …

4D BIM



4D BIM refers to the intelligent linking of individual 3D CAD components with time - or scheduling-related information. The use of the term 4D is intended to refer to the fourth dimension: time, i.e. 4D is 3D plus time schedule.

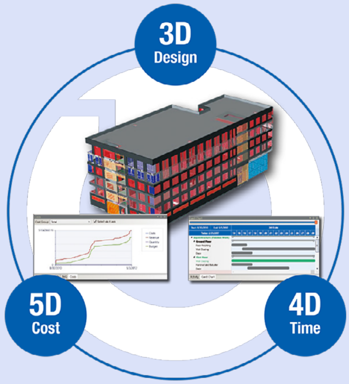
The construction plan of works information with 3D models is 4D enables the various participants (from architects, designers, contractors to clients) of a construction project,
to plan, sequence the
physical activities, visualize the critical path in the entire duration of a series of events,
mitigate the risks, reporting and
monitor progress of construction activities through the lifetime of the project.

5D AND 6D BIM

5D BIM refers to the intelligent linking of individual 3D CAD components or assemblies with time schedule (4D BIM) constraints and then with cost-related information:

5D = 3D + TIME SCHEDULE + COST

6D BIM, an acronym for 6-dimensional building information modeling and a term widely used in the Construction industry, refers to the intelligent linking of individual 3D CAD components or assemblies with all aspects of project life-cycle management information.



SOFTWARE PRODUCTS

- BIM requires specific tools that allow to produce geometry but also manage information.
- This is specially the case for software used by designers, because their work will be the core of the BIM process during construction.
- They will model the building but also define their requirements allowing contractors to use the embedded information.
- Some analysis tools do not require to be "fully BIM enabled" as long as they are able to import the needed information within the software (e.g.: tools that calculate thermal bridges).
- The better the software is able to communicate easily (without import/export or manual operations), the faster the overall process will be, the lower the risk of errors or data loss.

CERTIFIED SOFTWARE

- Some programs for BIM 3D parametric modelling: Autodesk Revit, Graphisoft ArchiCAD, Trimble Solutions Corporation Tekla Structures, and other necessary software:

Vendor	Product	Schema	Exchange Requirement	Import / Export	Status	Started	Completed	Report (link)
Trimble Solutions Corporation	Tekla Structures; ImportSDK (import)	IFC4	Structural Reference Exchange	Export	Finished	2017-10-02	2019-09-22	
NOVA Building IT GmbH	NOVA AVA BIM	IFC 2x3	CV 2.0	Import	Finished	2018-01-27	2019-07-11	https://ifc2x3.b-cert.org/ords/ifc/certification/getCertificationReport/883
ACCA Software S.p.A	CerTus-HSBIM	IFC 2x3	CV 2.0	Import	Finished	2018-04-10	2019-06-25	https://ifc2x3.b-cert.org/ords/ifc/certification/getCertificationReport/865
ACCA Software S.p.A	Edificus MEP	IFC 2x3	CV 2.0	Import	Finished	2019-04-12	2019-06-25	https://ifc2x3.b-cert.org/ords/ifc/certification/getCertificationReport/867
ACCA Software S.p.A	Solarius-PV	IFC 2x3	CV 2.0	Import	Finished	2018-04-10	2019-06-25	https://ifc2x3.b-cert.org/ords/ifc/certification/getCertificationReport/866

https://www.buildingsmart.org/compliance/software-certification/certified-software

HOW IS BIM USED IN CONSTRUCTION?

- Building Information Modeling could introduce a whole new level of transparency in the industry and transform the way people in construction design, collaborate and build.
- For that to happen, an impeccable BIM implementation and management plan is required.

Here are the main components of a successful BIM implementation and management process:

- Start with some BIM education.
- Roll out small.
- Escaping the labyrinth – How to stay in control of your supply chain
- Focus on digital adoption
- Go back and reiterate
- A culture shift comes from the bottom up.

https://www.letsbuild.com/blog/bim-implementation-and-management

1. Implementation of BIM
2. 4D BIM
3. 5-6D BIM
4. SOFTWARE PRODUCTS
5. BIM using in construction

41

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LESSON 4

Project Management using BIM

This lesson will introduce You to successful and easy project management when using BIM technologies.

WHY IS BIM IMPORTANT FOR PROJECT MANAGERS?

- Project managers have been left out of the mainstream action on BIM—partly due to lack of engagement on their part and partly because the frontend use of BIM in design has been in the limelight.
- This situation needs to change—effective project management is critical to ensuring successful BIM implementation and successful project delivery.

- ***"Project managers occupy a central role in the development process driving successful completion of projects."***

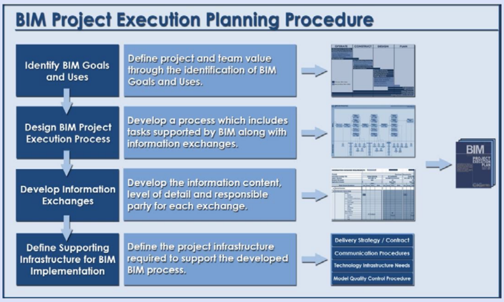
(RICS, 2015a)

BIM manager, coordinator

https://www.rics.org/globalassets/rics-website/media/knowledge/research/insights/bim-for-project-managers-rics.pdf

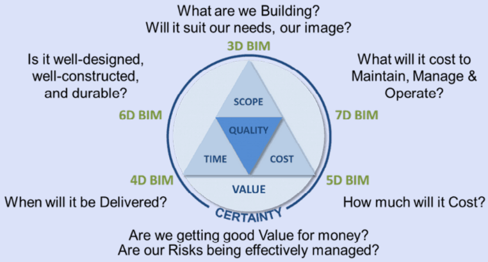
BIM EXECUTION PLAN (BEP)

The BIM Execution Plan (BEP) is a detailed plan that describe how the project will
be organized, executed and monitored. The aim of the BIM Execution Plan is to provide an plan that will guarantee all parties involved are clearly alert of the opportunities and responsibilities associated with projects that implement BIM.



THE FUTURE OF CONSTRUCTION PROJECT MANAGEMENT

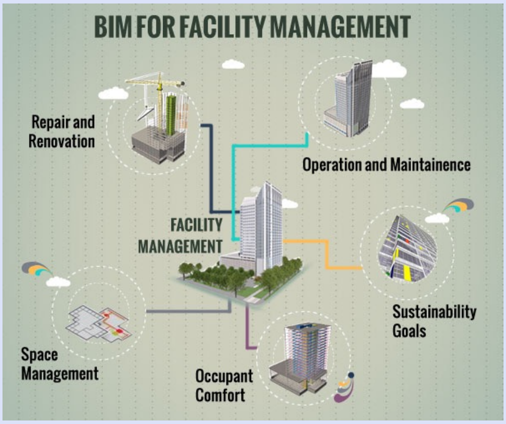
BIM are powerful tools for curbing the most common problems in construction and project delivery. The use of BIM in construction project management would be inevitable as it would give the edge to delivering high quality projects on time.



6D - 7D BIM

6D covers the sustainability targets for a building allowing information such as energy use, from a materials and management point of view to be understood and Leadership in Energy and Environmental Design (LEED) tracking to be performed.

7D - facility management, an important part of an AEC project. It is implemented once the construction phase is over.



8D – 9D BIM. 10D BIM?

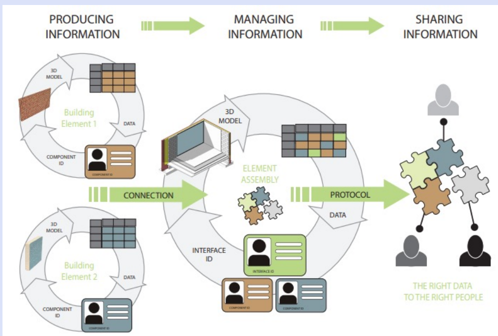
8D - BIM Modelling For Accident Prevention Through Design. Internet and installed things.

9D – building regulations and procurement.

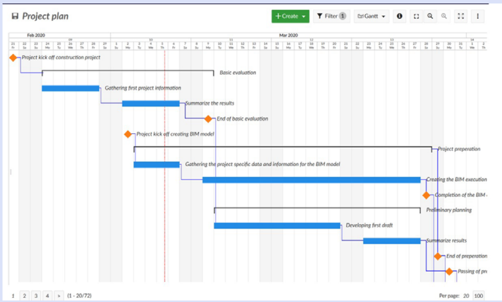
Future of AI and BIM - with constant technological progressions, next-generation 6D BIM is one of the necessary aspects of producing a flawless futuristic construction. Nevertheless, what is going to revolutionize and has now done in many cases, is the technologies and the processes that digitize the whole method by real-time visualization?

THE FUTURE OF CONSTRUCTION PROJECT MANAGEMENT

- As the core of BIM is not the geometry itself but rather more the information attached to it, the key of a successful BIM process resides in the way we deal with information.



PROJECT MANAGEMENT SOFTWARE



These days can take advantage of a host of project management software specifically designed for the construction industry to streamline project workflows.

This means you can easily make revisions, saving time and money and reducing the chance of errors.

Cloud-based solutions provide you with the tools to manage your project from pre-sale to completion, and include financial tools to keep you on budget, plus the ability to collaborate with clients and customers throughout.

1. BIM Important for Project Managers
2. BIM Execution Plan (BEP)
3. The future of construction project management
4. BIM and information
5. Future of BIM

50

LESSON 5

Other digital tools used in construction

In this lesson You will be introduced to other digital tools which can be used in construction and connected to the BIM.

DIGITAL TOOLS USED IN CONSTRUCTION

- BIM
- Project Management Software
- Smart Buildings
- HD Surveying and Geolocation
- 3D Printing
- Wearables
- Tool Tracking Devices
- New Materials
- Internet of Things
- Digital Collaboration and Mobility
- Virtual reality, VR, AR, mixed reality

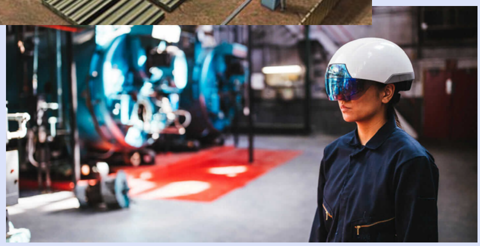
TOOLS FOR BIM

3D Printing

It's possible to print materials including concrete, steel and glass, and while this opens up many exciting possibilities, a major challenge moving forward is regulation.

Wearables

Wearables are something every project manager should be looking at. From smart helmets and smart glasses to smart vests with GPS and bionic suits that enable super-strength.



53

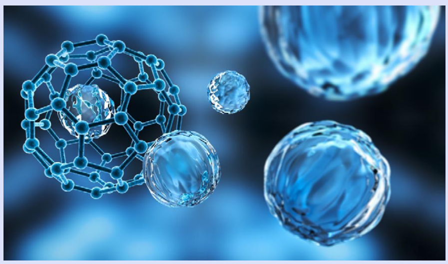
TOOLS FOR BIM

Tool Tracking Devices

Trackers consist of a small attachment that can be glued, screwed or strapped to your tools, which allows you to locate your tools using an app on your smartphone.

New Materials

Some examples include self-healing concrete that uses bacteria to mend its own cracks, super strong, ultralight nanomaterials, a topmix permeable cement alternative and the super-transparent insulating material aerogel.



54

TOOLS FOR BIM

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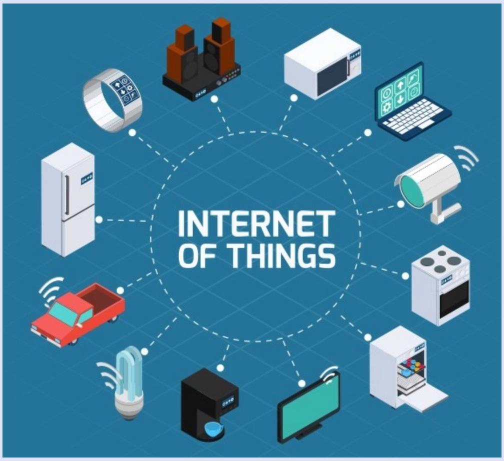
Internet of Things

Operating through sensors and wireless devices, the Internet of Things enables equipment, machinery, materials and structures to communicate data to a central platform.

Digital Collaboration and Mobility

With cloud-based, mobile-enabled platforms you can move away from paper to collaborate on and manage your projects digitally.



TOOLS FOR BIM

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The key for project managers is to keep up to date with the latest developments and recognise which of the new technologies and tools can improve the way you operate – both on the worksite and behind the scenes.

TOOLS FOR BIM

"When people begin to believe in the data, it's a game-changer: They begin to change their behaviors, based on a new understanding of all the richness trapped beneath the surface of our systems and processes,"
says Boeing CIO Ted Colbert.

THANK YOU!
QUESTIONS WELCOME

CHAPTER III:
CASE STUDIES

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DIGITALISATION OF CONSTRUCTION

CONDAP OPEN EDUCATIONAL RESOURCES

CASE STUDIES

1

CASE STUDIES

We are going to overview few BIM projects considering the information explaining in the lectures notes.

Europe has been very active in the implementation of BIM for public projects. There are more and more buildings that use this methodology to reduce time, costs and predict future problems along the project.

It was nominated TOP 10 Case Studies in Europe that showcase the power of BIM in www.bimcommunity.com

There is two projects in this material.

- **Locations:**
  - Paris (France)
  - Helsinki (Finland)

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2

CASE STUDY 1

The Clichy-Batignolles, a sustainable, net-zero carbon city neighbourhood of Paris

CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

Published by: BIMCommunity

Company: The Fifht Estate

Location: Paris, France

Source: https://www.thefifthestate.com.au/urbanism/planning/new-paris-district-shows-how-to-create-truly-sustainable-cities/99115

Published: 31/05/2018

Budget: 505.7 million €

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

- A regenerated neighbourhood of Paris is becoming a world-leading example of **how to construct a sustainable, net-zero carbon city** with Passivhaus design, renewables, biodiversity improvement, water sensitive urban design and smart waste practices.
- As befits the city that gave the world the Paris Agreement on climate change, the Clichy-Batignolles development is being constructed in line with the city's ambitious sustainable development policy, particularly its climate and biodiversity plans.
- Located on the site of an old railway yard in the 17th arrondissement in the city's north-west, the 54-hectare urban renewal project will eventually be home to 7500 residents and provide employment for at least 12,000. At its heart is a 40,000 square meter park.

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

- At a total cost of €505.7 million it will eventually comprise a judicial centre, theatre, cinema, 495,000 sq m of real estate including 200,000 sq m of housing (of which half is social housing, 30 per cent owner-occupied, and 20 per cent intermediate), 105,210 sq m of offices, 25,000 sq m of shops, and 28,000 sq m of public facilities.
- The area along Avenue de Clichy, containing 1400 housing units, is now complete. Construction is underway on the other bank of the park and at the Porte de Clichy, and will be finished by 2020.
- The district was awarded an EcoQuartier label from the Ministry of Housing and Sustainable Housing in 2016, won the Sustainable City Grand Prize in the international Green City Solutions Awards, and received European funding for the creation of the first smart grid in Paris.

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

- A range of plants are also found alongside roads, landscaped island cores, 6500 sq m of private gardens for residents to grow food and 16,000 sq m of green roofs. Two further community gardens give opportunities to grow food and compost food waste.
- The park forms part of a chain of green spaces that threads through Paris, including Parc Monceau, Bois de Boulogne, several squares (including those of Batignolles and Épinettes) and the cemeteries of Montmartre and Clichy.
- Waste (except for glass) is collected by an underground pneumatic network and sucked into a collection terminal on a nearby boulevard from where it is distributed to treatment and recycling centres. By removing the need for lorry collection this reduces greenhouse gas emissions by 42 per cent, carbon monoxide emissions by 98 per cent, nitrogen oxide emissions by 86 per cent and particulate emissions by 90 per cent.

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

Project management

- The project is managed by a public local development company, Paris Batignolles Aménagement. This is a public limited company with a capital of €6 million (AU$9.24 million), 60 per cent owned by the City of Paris and 40 per cent by the Paris Department.
- It was created in 2010 to lead the development of Clichy-Batignolles, and subsequently given responsibility for the whole of Paris. Since December 2016, Paris Batignolles is in charge of four more developments: Saint-Vincent-de-Paul; Pouchet Gate; Paul Meurice sector, Porte des Lilas neighbourhood; and Chapelle-Charbon.
- A team of 26 experts is headed by Jean-François Danon, who works closely with deputy mayor Jean-Louis Missika, responsible for urban planning, architecture, the project of Greater Paris, economic development and attractiveness.

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

The challenge of reducing energy use

- Despite all of this effort, the energy use of the first residents is higher than the design team expected, **so the buildings have not quite achieved net zero carbon emissions.**
- A team (called CoRDEES – Co-Responsibility in District Energy Efficiency & Sustainability) is working to reduce this gap by using a €4.3 million (AU$6.62 million) award from the European Union's Urban Innovative Actions Initiative to develop smart grid technology. This will be a community-based system to help residents monitor and manage their energy use.
- The Community Energy Management Platform will process energy data from buildings and public facilities in real time to define optimization scenarios. It aims to achieve the objectives of the climate change plan, to emit 90 per cent less CO_2 and satisfy Passive house requirements.

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

This is expected to create a new economic model based on energy savings and the creation and perpetuation of new services.

"Smart grids at the local level are central to build a zero carbon city," Jean-Louis Missika said.

"With the CoRDEES project, we experiment with smart grid solutions and effective governance to reach ambitious energy performance targets. We hope the Clichy-Batignolles eco-district will act as a model for other cities."

All of this will allow Paris to demonstrate excellence in sustainability, showing how cities can become carbon neutral and provide a home for both nature and people.

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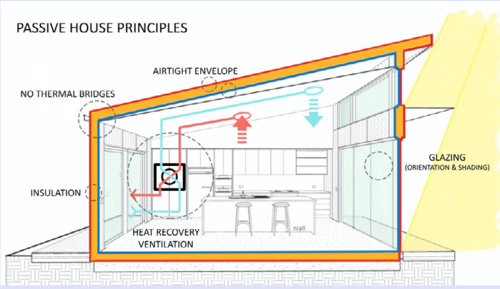
CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS



Passive house building

- All buildings are being constructed to the demanding Passivhaus standard, meaning that the energy consumption required for heating is just 15 kilowatt-hours a square metre of floor space per year, and the overall energy consumption is under 50kWh asqm of floor space per year.
- The buildings are south-facing and super insulated, capturing and retaining the sun's heat and warmth given off by their occupants and technology. Buildings are composed of renewable materials while other materials such as PVC are banned.

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CASE STUDY 1. THE CLICHY-BATIGNOLLES, PARIS

- The area will contain 40,000 sq m of solar photovoltaic roofs that will eventually generate around 4500-megawatt-hours a year to supply 85 per cent of the remaining energy needs, while deep geothermal energy will provide 83 per cent of the space heating and domestic hot water, so that the entire site will have a carbon neutral footprint.
- Following the guidelines of the biodiversity plan, the development's Martin Luther King Park contains over 500 species planted around a wet ditch and a biotope basin, which forms part of the sustainable urban drainage design. Combined with permeable surfaces linked to underground reservoirs, rainwater run-off is about half that of conventional projects, to minimise pollution and irrigate the park.

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CASE STUDY 2

Easton Commercial Centre, Helsinki

CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

PUBLISHED BY:

Lahdelma & Mahlamäki Architects

Company: Lahdelma & Mahlamäki Architects

Location: Helsinki, Finland

Year of the project: 2017

Published: 04/01/2019

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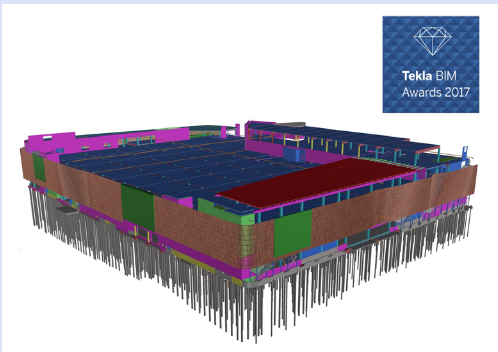
CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

- Easton Helsinki, a 66,000 m2 shopping centre by Lahdelma & Mahlamäki is the first phase in a larger urban plan and looks to celebrate the **identity and culture of Helsinki's eastern districts**. In its architectural and commercial concepts the project idealistically and physically centres itself around food, bringing together local vendors and businesses at the heart of the shopping centre. However, the project also holds a rich production history – it has been as much about process as it has about the final result.

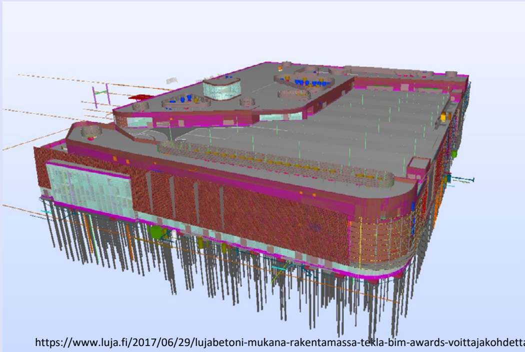
CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

- Centralised BIM models have formed the core of the workflow and design process since day one, a request of the client Kesko.
- Whilst shopping centres are inherently complex projects, workflow on all levels, from the design desks of individual end-users to contractors on-site, was managed through a centralised model; whether it be involving the façade system or the environmental conditions of individual shops.
- Easton offers 30,000 m2 of rentable commercial floor space which is set to bring 40 businesses into the area, with the emphasis being put on healthy foods and creating an everyday social atmosphere around this.



CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

- The size and complexity of these programmes and involved parties brought a challenging timetable to all levels of construction and design. To manage this, template-based workflows were used which **enabled quick design cycles and the efficient transfer of output data.** This arrangement of working meant that many processes could happen simultaneously which massively boosted the efficiency of the project.
- Whilst construction work was ongoing, **Kesko could use the comprehensive BIM model as a way of negotiation and planning future retail spaces with prospective tenants** who were able to accurately present future operating environments. One of its primary uses was indeed as a decision tool for current and future stakeholders, clients and partners. Kesko themselves use BIM to model their shops, which can be added into the central design and construction model of the shopping centre.



https://www.luja.fi/2017/06/29/lujabetoni-mukana-rakentamassa-tekla-bim-awards-voittajakohdetta/

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17

CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

- The creation and management of the model was an impressive feat. The model was under the central control of Haahtela-rakennuttaminen Oy, but each separate contractor would be required to update it as changes were made.
- The model was used to coordinate the building services, structures and architecture during the design process.
- Then, during construction, various sub-contractors were able to inspect the model and make decisions based on it, before installations actually began.

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- The thoroughness of the model allowed them to engage with the design in more progressive ways. For example, the HVAC designers were able to inspect the pipe and duct installations up close, before their construction, in virtual reality. If alterations were made on site, then the BIM model would also be updated to reflect this. As a result, the end model is a direct representation of the building on site and is technically correct.
- The client set this as a key requirement in order for the model to be used in the future for maintenance and development purposes.

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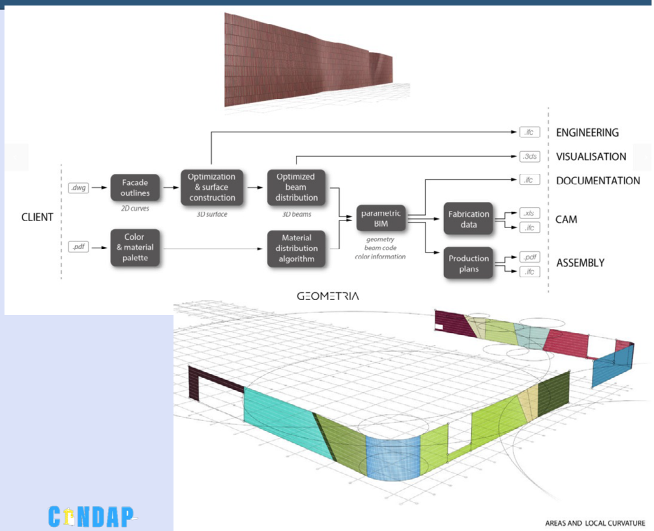
CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

- At first glance the most striking feature and most clearly a result of computer modelling, is the gently undulating façade which evolves the local red-brick aesthetic into an array of 100,000 ceramic and aluminium rods backed by a steel structure.
- Geometry specialists *Geometria* modelled and were able to accurately map each façade element, its angle, length and colour, across the huge undulating façade, initially using algorithms based on Rhinoceros and Grasshopper but which then fed into the centralised model. The data from the structural models entered a back-and-forward process between the design studio and the model shop – always being fed back into the central model – eventually becoming realised as pre-assembled units ready to go on site.

http://www.geometria.fi/project/easton-commercial-center/



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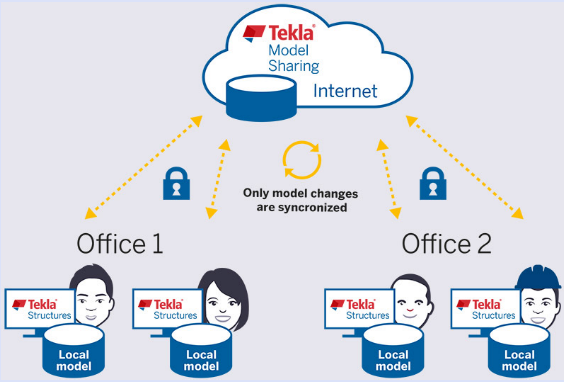
CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

- The adoption and integration of technologies was widely appreciated amongst all contractors. **Output data from changes to design elements was virtually real-time as structural and elemental designers** worked in the same model environment with Tekla Model Sharing. Frame options were compared with Tekla Structures and Vico Schedule Planner, and the designers of each component were able to pull information such as element weights and locations obtained from the model.
- The direct result of this was that the façade frame, the structure was optimised for the most effective timetable and best costs, and allowed for the safe installation of the frame. Changes could also be made without the interruption of the rest of the project.



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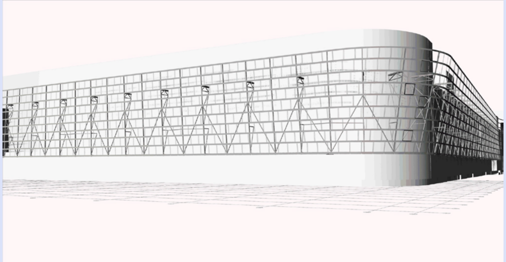
21

CASE STUDY 2. EASTON COMMERCIAL CENTRE, HELSINKI

The opinion of all partners, upon completion of the project, was that the **transparency and integration of the design process was hugely successful and allowed everyone to approach all challenges** and respond to them in a noticeably clearer and more organised manner than a more traditional construction environment. The obvious testament to this is that the complex project was completed according to the agree timetable – which is vital for a commercial project of this size – not only this but, the project was awarded the Tekla BIM Award 2017.



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CHAPTER IV:

EXERCISES

4.1. MULTIPLE CHOICE QUESTIONS

[1] What does BEP stand for?

a. BIM Execution Plan

b. BIM Extraction Plan

c. BIM Executables Plan

[2] Building information modelling (BIM) is:

a. organisation in Europe

b. result of the construction project

c. process

[3] Building information models (BIMs) are:

a. buildings

b. drawings

c. files

[4] IFCs have been developed by………………., as a neutral, non-proprietary or open standard for sharing BIM data among different software applications:

a. ISO department

b. Construction company

c. buildingSMART

[5] Building Information Modelling is ………………. of physical and functional characteristics of a facility creating a shared knowledge resource for information about it and forming a reliable basis for decisions during its life cycle, from earliest conception to demolition.:

a. presentation

b. protocol

c. digital representation

[6] According to the Mark Bew and Mervyn Richards table, the number of levels as 'maturity levels' are:

a. 7

b. 3

c. 4

[7] Sentence "CAD including 2D drawings, and text with the paper-based or electronic exchange of information" belongs to description of maturity level:

a. 1

b. 4

c. O

[8] LOD ….. = "there is a chair":

a. 150

b. 400

c. 100

[9] 4D BIM refers to the …… …… …………….. :

a. project

b. health

c. intelligent linking of individual 3D

[10] 4D BIM is:

a. 4D geometrical object

b. Software name

c. Time schedule

[11] Software for BIM:

a. Corel Draw

b. Solitaire

c. Autodesk Revit

[12] The BIM Execution Plan (BEP) is a detailed____________ that describe how the project will be organized, executed and monitored.

a. Drawing

b. Table

c. Plan

[13] The virtual building model in a BIM project, called a BIM model, serves as the foundation of the project:

a. False

b. True

[14] In a typical CADD workflow, ……………. drawings are created to represent the building:

a. isometrical

b. 4D

c. 2D

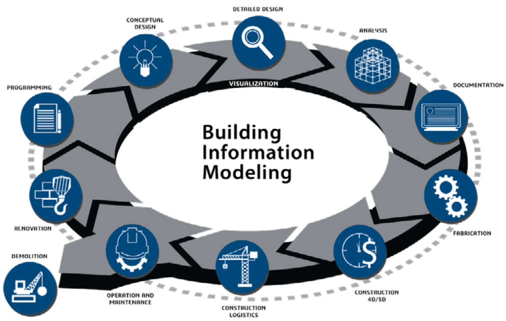
[15] Digital tool used in construction:

a. Digital pencil

b. Virtual paper

c. 3D printing

[16] Which part of the building lifecycle is missing:



a. Map

b. Schedule

c. Analysis

[17] BIM concept is defined as follows – building is ………… building model, taking into account the whole building lifecycle: design, construction, management

a. 2D

b. economical

c. three-dimensional

[18] BIM ensures integrated management of graphic and information data flows via coordination of virtual graphic workspace (CAD) with data bases (DB) and document management means (PDM).

a. False

b. True

[19] BIM basis - parametric modelling:

a. False

b. True

[20] In the application Autodesk REVIT Architecture you work only with graphic information building model, and drawings (layouts, facades, sections, 3D views, etc.) as well sheets of materials and products are generated from the model automatically.:

a. False

b. True

4.2. SHORT RESPONSE QUESTIONS

[1] Identify some of the current reasons of BIM implementation in the construction sector.

Efficiency – collaboration – low cost

[2] What does BEP stand for?

BIM Execution Plan

[3] What are BIM tools?

BIM authoring software

[4] Some of the software is used for BIM.

Revit, Navisworks, ArchiCAD

[5] Short name of Employer's Information Requirements

EIR

[6] In a typical CADD workflow, _______ drawings are created to represent the building.

3D

4.3. FREQUENTLY ASKED QUESTIONS

[1] What means term digitalization?

Digitization, digitalization, or Digital Transformation (DT or DX) is the use of new, fast, and frequently changing digital technology to solve problems.

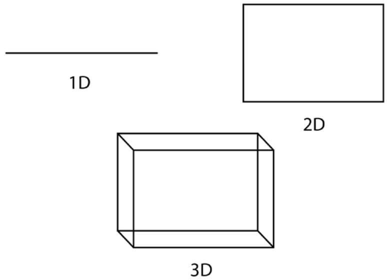
Using of the digital transformation are in Computer aided design, BIM, cloud computing etc.

[2] What is CAD?

The concept of computer-aided graphics has been defined in 1962, when MIT scientist Ivan Sutherland (USA) has developed the first graphical editor Sketchpad. From then, fast development of drawing and space modelling software has begun and the concept CAD (Computer Aided Design) was finally settled belongs. Computer-aided design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

[3] What difference are between 2D and 3D?

2D and 3D refer to the actual dimensions in a computer workspace. 2D is "flat", using the horizontal and vertical (X and Y) dimensions, the image has only two dimensions and if turned to the side becomes a line. 3D adds the depth (Z) dimension. This third dimension allows for rotation and visualization from multiple perspectives.



[4] Most popular software for CAD

Most reviewed on 2020 year commercial 3D Architecture CAD Software with annual subscription are Roomle, PlusSpec, SketchUp, BricsCAD, AutoCAD, etc. All list is on page www capterra com.

[5] Most popular software for BIM

Best Building Information Modeling Software at 2020: Autodesk BIM 360, Tekla BIMsight, Revit, Navisworks, Archicad, Trimble Connect etc. All list is on page www financesonline com.

[6] What are Maturity levels?

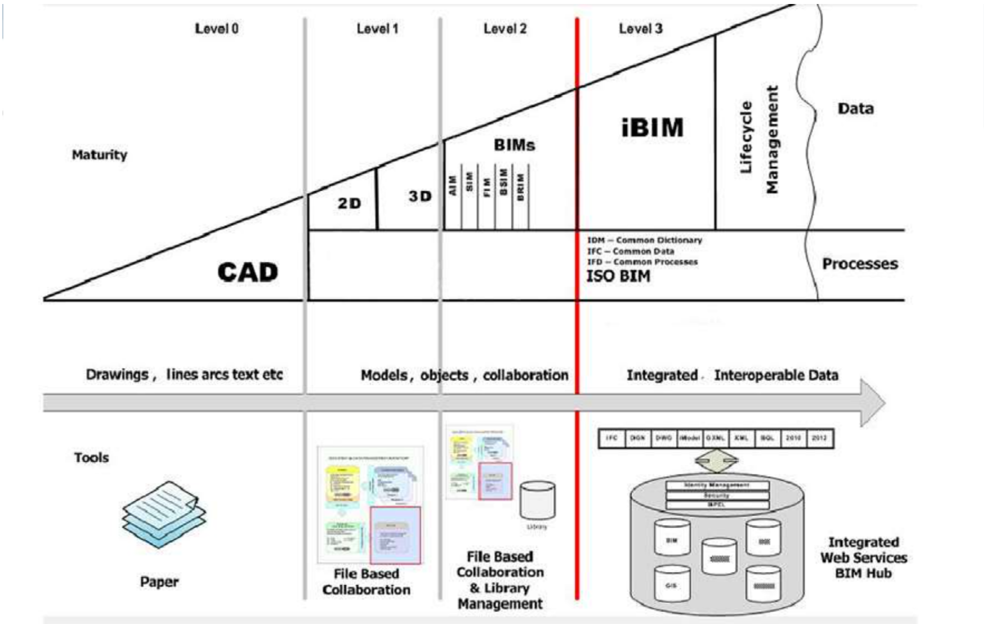
Level 0: Unmanaged CAD (Computer Aided Design).

Level 1: Managed CAD in 2D or 3D.

Level 2: Managed 3D environment with data attached but created in separate discipline models.

Level 3: Single, online, project model with construction sequencing, cost and life-cycle management information.

The Bew and Richards BIM Maturity Levels Model (Bew and Richards, 2008):



[7] How much maturity levels are in BIM?

In Bew-Richards model (1988) we can see four levels. Now are additional levels in BIM world. The range of levels that this form of modelling can take are described as *'maturity levels' and are described below.*

Level 0 BIM. Unmanaged computer aided design (CAD) including 2D drawings, and text with paper-based or electronic exchange of information but without common standards and processes. Essentially this is a digital drawing board.

Level 1 BIM. Managed CAD, with the increasing introduction of spatial coordination, standardised structures, and formats as it moves towards Level 2 BIM. This may include 2D information and 3D information such as visualisations or concept development models. Level 1 can be described as 'Lonely BIM' as models are not shared between project team members.

Level 2 BIM. Managed 3D environment with data attached but created in separate discipline-based models. These separate models are assembled to form a federated model, but do not lose their identity or integrity. Data may include construction sequencing (4D) and cost (5D) information. This is sometimes referred to as 'pBIM' (proprietary BIM).

Level 3 BIM. A single collaborative, online, project model with construction sequencing (4D), cost (5D) and project lifecycle information (6D). This is sometimes referred to as 'iBIM' (integrated BIM) and is intended to deliver better business outcomes.

Level 4 BIM. Level 4 introduces the concepts of improved social outcomes and wellbeing.

[8] What means IFC?

The Industry Foundation Classes (IFC) data model is intended to describe architectural, building and construction industry data. It is a platform neutral, open file format specification that is not controlled by a single vendor or group of vendors. It is an object-based file format with a data model developed by buildingSMART (formerly the International Alliance for Interoperability, IAI) to facilitate interoperability in the architecture, engineering and construction (AEC) industry, and is a commonly used collaboration format in Building information modeling (BIM) based projects. The IFC model specification is open and available. It is registered by ISO and is an official International Standard ISO 16739-1:2018.

[9] What is buildingSMART?

BuildingSMART is the worldwide industry body driving the digital transformation of the built asset industry. buildingSMART is committed to delivering improvement by the creation and adoption of open, international standards and solutions for infrastructure and buildings. buildingSMART is the community for visionaries working *to transform the design, construction, operation and maintenance of built assets. buildingSMART is an open, neutral and international not-for-profit organization.*

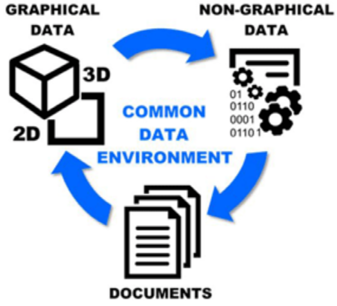
[10] How and who works in BIM collaboration?

Building Cloud technology and BIM collaboration, is enabling teams to become more connected, and have access to information from anywhere and anytime.

The cloud for instance connects data, systems, projects, and teams, so that everything and everyone can be in constant communication, with instant access to the updated files, designs and project activity.

[11] What is CDE?

The common data environment (CDE), is the single source of information used to collect, manage and disseminate documentation, the graphical model and non-graphical data for the whole project team (i.e. all project information whether created in a BIM environment or in a conventional data format). Creating this single source of information facilitates collaboration between project team members and helps avoid duplication and mistakes. PAS1192-2 defines the Project Information Model (PIM) and Asset Information Model (AIM) as the combination of graphical data, non-graphical data and documents related to a building or construction project, all stored and managed in a Common Data Environment (CDE).



https://www.thenbs.com/knowledge/building-information-modelling-what-information-is-in-the-model

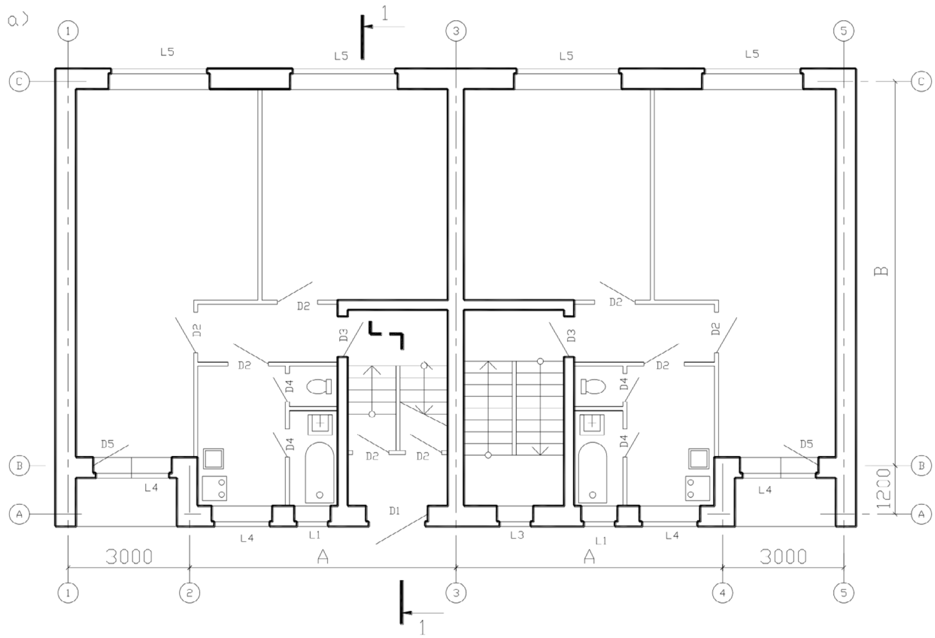
4.4. TIMED CATEGORIZATION EXERCISE

Small living building concept and drawing

Small building project:

Your task is to make the 3D model of house.

Dimensions for the plan: A – 6000 mm, B – 9200. Place the axis grid by given dimensions. Model of a house can be made with any BIM software (Revit, ArchiCAD etc). Façade and section 1-1 should be made too. Select any dimensions for the house elevation and rooms.



Time for task preparing – 10-15 hours.

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