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BIM

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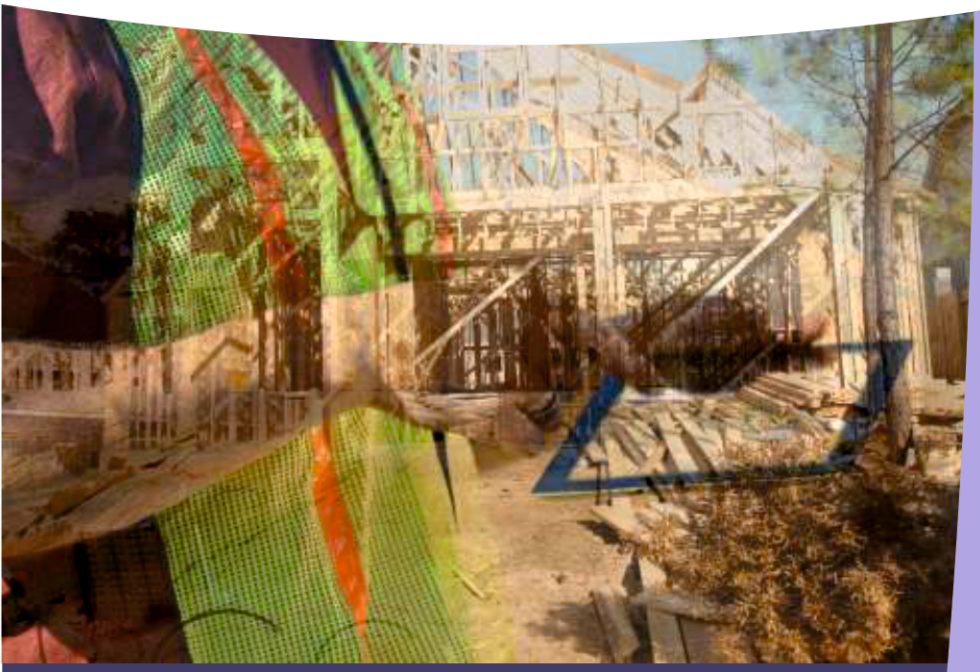

Matrix of professional competences for digital building

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Project Coordination

BGZ Berliner Gesellschaft
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www.bgz-berlin.de

www.fit4bim.eu

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INTRODUCTION

The main topic of the project is "Building Information Modeling". (BIM) understood as a method of digital design, implementation and management of buildings which is now becoming a standard throughout the EU. The project partners are eight vocational training centres and universities from Germany, Poland, Denmark and Belgium - working under the leadership of BGZ (Berlin International Cooperation Agency GmbH) and are supported by various business associations, chambers of commerce and construction companies.

The project analyses among others:

- what professional requirements in the field of digitization will be faced by qualified professionals in the construction industry;
- what should be the future of vocational education institutions and universities in order to be able to transfer digital competences in a practical way;

Selected project activities(www.fit4bim.eu):

- networking at local, regional, national and EU level;
- development and testing of educational material on digital technologies in construction;
- promoting the dissemination and transfer of project solutions in the four partner countries and the whole EU;
- development of a matrix of professional competences in digital technologies in construction.

In the work on the project, multifaceted research has been used, using the experience gained in foresight studies, in which the scientific and practical community jointly identifies important aspects of the analyzed issue, determines the strength and directions of their impact. In the selection of research methods the principle of triangulation of researchers and methods was applied. The working and discussion groups were attended by representatives of: central authorities (members of the Polish Parliament), research and development units (members of the Polish Association of Construction Engineers and Technicians (PZITB - Polish Association of Construction Engineers and Technicians, members of the "BIM for the Polish Construction Industry" Association), universities, teachers of vocational subjects from secondary technical schools, entrepreneurs (small, medium and large companies from the construction industry). Triangulation of methods consisted in their selection from among the methods collected in the foresight diamond [1], in which four poles are: creativity, interaction, data and expertise. The location of methods in a diamond was relatively evenly distributed to make the best use of the variety of data sources and ways of collecting information. Literature review, expert panels, surveys, STEEPVL analysis and brainstorming were selected as qualitative studies and structural analysis as quantitative studies.

The authors of the study took part in national conferences, as well as organized discussion meetings in order to exchange experiences with practitioners from the industry and with lecturers from other universities, where BIM topics are also introduced into the curriculum. At the Poznan University of Technology, Faculty of Construction and Environmental Engineering, the members of the advisory board developing the educational methods are representatives of design and construction companies.

The project partners, thanks to their participation in the Fit for BIM project, had the opportunity to exchange experiences with environments where BIM has been used for a long time.

COMPETENCE SYSTEMS

EUROPEAN COMPETENCE SYSTEM

The European Qualifications Framework is recommended by the Council of the European Union [2, 3] to compare qualifications systems in European education systems. Eight levels of education were established, for which three categories of learning outcomes were prepared: knowledge, skills, responsibility and autonomy.

The project prepared competence matrices for education levels: 3, 4, 5 and 6.

Level	Knowledge	Skills	Responsibility and autonomy
3	knowledge of facts, principles, processes and general concepts in a given field of work or study	a set of cognitive and practical skills needed to perform tasks and solve problems by selecting and applying basic methods, tools, materials and information	accepting responsibility for carrying out tasks at work or learning adapting one's behavior to the circumstances when solving problems
4	factual and theoretical knowledge in a broader context of a given field of work or study	range of cognitive and practical skills needed to solve specific problems in a given field of work or study	self-organization within the guidelines of work-related contexts or
5	extensive specialist factual and theoretical knowledge in a given field of work or study and awareness of the boundaries of this knowledge	a comprehensive range of cognitive and practical skills needed to creatively solve abstract problems	learning, usually predictable, but subject to change, overseeing the routine work of others, assuming some responsibility for assessing and improving work or study activities
6	advanced knowledge in a given field of work or study, including critical understanding of theories and principles	advanced skills, demonstrating proficiency and innovation needed to solve complex and unpredictable problems in a specialized field of work or study	management and supervision in work or study contexts subject to unpredictable changes analyzing and developing own and other people's achievements management and supervision in work or learning contexts subject to unpredictable changes analyzing and developing own and other people's achievements

The Council Recommendation on key competences for lifelong learning of 17.1.2018 [4] stated, among others, that 44% of the EU population has underdeveloped digital competences despite the significant impact of the pace of technological and digital change on our economy and society. Key competences include IT competences. It was recommended to respond to changing requirements in relation to digital competences.

NATIONAL COMPETENCE SYSTEMS IN PARTNER COUNTRIES

National qualifications systems are based on the European Qualifications Framework. Learners, graduates, education and training providers and employers can thus better understand and compare qualifications awarded in different countries and in different education and training systems [2].

TYPES OF BIM ANALYZED PROFESSIONS

3TH LEVEL OF EDUCATION

Vocational education at level 3 means learning in a first level of professional school. The following occupations were analysed in the project:

- roofer (PL),
- fitter of building and finishing works in construction (PL),
- construction worker (DE)
- auxiliary worker (DE).

4TH LEVEL OF EDUCATION

Vocational education at level 4 means learning at a vocational secondary school or technical school. The project analysed the professions:

- building technician (PL),
- finishing techniques (PL),
- draftsman (DE, BE, DK),
- concrete worker, armourer (DE),
- bricklayer (DE, DK),
- carpenter (DE, BE, DK).

5TH LEVEL OF EDUCATION

Vocational education at level 5 means upper secondary education. This type of school does not exist in all EU countries. The project analysed the profession of construction technicianin Denmark (DK).

6TH LEVEL OF EDUCATION

Vocational education at level 6 means first degree studies at Universities and Higher Vocational Schools. The following occupations were analysed in the project:

- a civil engineer (PL, DE),
- architect engineer (PL),
- construction architect (DK),
- architectural technology and construction management engineer (DK).

INITIAL REQUIREMENTS FOR LEVELS 5 AND 6

The student …	DK	DE	PL
Knows the rules for preparing tender documentation	x	x	x
Has knowledge of the scope of competences of the different professions involved in a building project	x	x	x
Can communicate in a relevant foreign language	x	x	x
Knows the technical vocabulary of own discipline in a relevant foreign language	x	x	x
Is able to cooperate across disciplines in acknowledgement of the competencies and priorities of other disciplines	x	x	x
Can find software and software usage tutorials that can help in the development of the project	x	x	x
Can use modern methods of information exchange (internal network, internet, data storage clouds, cloud computing)	x	x	x
Can make well-structured searches on the internet	x	x	x
Is able to independently handle and maintain functionality of hardware and software	x		
Is able to independently seek out relevant help to hardware or software problems	x		
Is able to independently assess and apply the relevant use of common generic software in various contexts	x	x	x
Knows the principles of descriptive geometry and technical drawing in the field of reading and drawing working drawings and documentation (architectural, construction, geodetic maps and others depending on the industry) with the use of CAD			x
Can read, execute, edit and print drawings of documentation (architectural, construction, surveying maps and others depending on the industry) using CAD			x
Knows the sequence of consecutive stages of the design and construction stages			x
Knows the methods of planning the construction process (or demolition) of a building object			x
Is able to take into account unforeseen changes occurring during the construction process and is able to introduce modifications to the schedule and assess their impact on the entire process			x

MATRIX OF BIM COMPETENCE FOR INDIVIDUAL EDUCATION LEVELS - CURRENT STATE

The following tables present the current state of competences in the matrices of the analysed schools and universities.

3TH LEVEL OF EDUCATION

3	Knowledge				
	-	DK	DE	BE	PL
Digital documentation	Knows different digital documentation devices and their fields of application.			x	
	Has knowledge of the connection structure between digital documentation instruments.			x	
	Has knowledge of connecting digital documentation instruments with digital terminals / knowledge of storage and dispatch options.			x	
	Knows different digital communication devices and their fields of application.			x	
Digital measurement	Is familiar with different digital measuring and documentation devices and their application areas application.		x		
	Has knowledge of operating digital measurement and documentation tools.		x		
	Has knowledge of how to connect digital measurement and documentation instruments to digital devices / to enter data into digital devices.		x		
	Knows formats for saving in the required manner, export.		x		
Digital drawing 2D	Has knowledge about the layer structure. Knows the basics off digital drawings, according to national standard. Knows the devices and their application areas application.	x			
Handling 3D models	Has knowledge how to handle and apply 3D CAD drawings in conjunction with the construction process, according to national standard.	x			
	Has knowledge about the layer structure when drawing up relevant work drawings. Knows how to create new 3D CAD drawings, thus contributing constructive and relevant suggestions to current ones constructs.	x			
	Has knowledge how to complete cross-sections and facades from finished 3D object-based floor plans.	x			
Digital calculation	Knows the characteristic elements included in the cost estimates.				x
	Knows how to distinguish types of cost estimates, inputs, labor, materials, equipment.				x

3	Skills				
	-	DK	DE	BE	PL
Digital documentation	Can select suitable digital devices for creating the digital documentation.			x	
	Can establishing a connection between digital devices.			x	
	Can store and transfer of ascertained data.			x	
	Can select and operate suitable communication devices.			x	
Digital measurement	Can select suitable digital devices for recording the planning measures / planning information.		x		
	Can use digital surveying and documentation tools.		x		
	Can transmit the determined data to a digital terminal.		x		
	Can export the data in suitable form for further use.		x		
Digital drawing 2D	Can use an electronic-based drawing program to create 2D object-based floor plans in various levels of detail according to standard drawing requirements.	x			
	Can use the BIPS layer structure to measure floor plans and apply text.	x			
	Can create and edit their own plan, cut and draw patterns, and move from drawing to drawing.	x			
	Can draw sketches with his hand. Can design drawings to the correct scale.	x			
	Can use a CAD program to create simple working drawings with plan- and page images.	x			
	Is familiar with drawing and using views.	x			
	Can use the geometry capabilities of CAD programs as well as editing and manipulation tools.	x			
	Is aware of and can apply the legal structures, including the use of ingots according to the building standards	x			
Handling 3D models	Can use IT items.	x			
Digital calculation	Can read the catalog of material inputs.				x
	Can explain the principles of making cost estimates, that is, the technique of making.				x
	Can determine the output data for cost estimates.				x
	Can read documentation, specifications.				x
	Can read the essential conditions for the acceptance of works.				x

3	Responsibility and autonomy				
	-	DK	DE	BE	PL
Digital documentation	Is aware that he carry out digital documentation on their own responsibility. Knows how to communicate with the in-house hierarchy.			x	
Digital measurment	Is aware that he is self-responsible for an oversize and that he should pay attention to the construction site safety. Knows how to communicate with the participants regarding specific requirements. Knows how to communicate with the in-house hierarchy.		x		
Digital calculation	Is able to apply the principles of personal culture				x
	Is able to apply the rules of professional ethics				x
	Is able to analyze jointly the changes taking place in the industry in the field of calculation				x
	Is able to take new calculation challenges				x
	Is able to be open to the use of new methods and work techniques				x
	Is able to accept readiness for continuous learning and professional development in the team				x
	Is able to use different sources of information to improve professional skills				x
	Is able to work in a small and large calculation team				x

4TH LEVEL OF EDUCATION

4	Knowledge				
	-	DK	DE	BE	PL
BIM technology / philosophy, Modelling / Drawing, Data management	Has knowledge about commands for creating and modifying a project file		x	x	
	Has knowledge about commands for modelling of existing construction components (library, database)		x	x	
	Has knowledge about commands to modify the construction components (position, attributs, level, …)		x	x	
	Has knowledge about bim objects in external database/libraries		x	x	
	Has knowledge about graphical commands		x	x	
	Has knowledge about demensioning and labeling		x	x	
	Has knowledge about layout functions and scale settings		x	x	
	Has knowledge about printing and exporting (PDF) a plan		x	x	
Visualization	Has knowledge how, by using a 3D design program, can produce visualizations with the insertion of light and camera on building components: • Using the 3D visualization part of a 3D design program, knows how to compose animations of buildings and components that show the composition of the section. • Knows how to set up fixed and moving light sources • Knows how to insert and set a fixed camera position • Knows how to render images based on his own image quality	x			
	Has knowledge how, by using a 3D design program, can make simple animations, including movie sequences of buildings and components that show the composition of the section: • Knows how to insert moving camera • Knows how to edit the camera • Knows how to adjust camera settings • Knows how to set up fixed and moving light sources • Knows how to insert and set a fixed camera position • Knows how to render images based on his own image quality • Knows how to insert moving camera • Knows how to edit the camera • Knows how to adjust camera settings	x			
Calculation	Has knowledge how to distinguish types of cost estimates, inputs, labor, materials, equipment				x
	Knows characteristic elements included in the cost estimates				x
	Knows what is the difference between computer programs for making cost estimates				x

4	Skills				
	-	DK	DE	BE	PL
BIM technology / philosophy, Modelling / Drawing, Data management	Can use and modify a template.		x	x	
	Can model the different construction components		x	x	
	Can modify the construction components		x	x	
	Can import bim objects		x	x	
	Can use the graphical commands		x	x	
	Can demension and label the view.		x	x	
	Can create layouts and plans in 2D		x	x	
	Can print and export a plan		x	x	
Visualization	Can produce visualizations with different lighting phrases with the use of 3D software: • Daylight • Friendly lighting outside • Favorite lighting inside	x			
	Can set up set / adjust fixed light source: • Light lights inside • Stand lights inside • Light under the suspension • Lighting in driveway • Course list / interim goals (continued)	x			
	Can conduct light study based on the sun's movement during one day (shadow effect on property / property): • Solar Study • Sun Parth	x			
	Can create images, rendering, showing your building from and to each room: • Photos from different positions and different heights outside • Photos of each room • Photos of different quality • Photos with different lighting	x			
	Can make a simple animation, walkthrough, which shows the building exterior / inside: • Overall height levels / camera angle adjustment outside • Image inside the building / camera height / angle adjustment	x			
Calculation	Can read the catalog of material inputs				x
	Can explain the principles of making cost estimates, that is, the technique of making				x
	Can determine the output data for cost estimates				x

	Can apply computer techniques in the preparation of cost estimates				x
	Can read documentation, specifications				x
	Can read the essential conditions for the acceptance of works				x

4	Responsibility and autonomy				
	-	DK	DE	BE	PL
BIM technology / philosophy, Modelling / Drawing, Data management	The school is able to has a close cooperation with the business community in developing and planning courses and courses (the interaction creates the best quality in education and training)	x			
	The school has a culture of learning that focuses on high professionalism (everyone wins by focusing on empowerment of the individual)	x			
	The school has a learning culture, where recognition is a bearing principle (a recognizable approach both supports the development of the individual and provides space for diversity)	x			
	The teaching is based on the individual and builds on his / her professional and personal skills, individual wishes and opportunities, as well as prepares the individual for business or further education (differentiation creates motivation and challenges the individual's learning and development)	x			
	The teaching is organized so that there is a link between theory and practice (the link gives concrete skills and a holistic understanding of the reality that the individual is acting in)	x			
	The teaching is planned and evaluated in dialogue with the students, the students or the course participants (dialogue supports co-responsibility for self-learning and learning in interaction with others)	x			
Calculation	Is able to apply the principles of personal culture				x
	Is able to apply the rules of professional ethics				x
	Is able to analyze jointly the changes taking place in the industry in the field of calculation				x
	Is able to take new calculation challenges				x
	Is able to be open to the use of new methods and work techniques				x
	Is able to accept readiness for continuous learning and professional development in the team				x
	Is able to use different sources of information to improve professional skills				x
	Is able to work in a small and large calculation team				x

5TH LEVEL OF EDUCATION

5	Knowledge		
	-	DK	DE
BIM technology / philosophy	Knows BIM terminology.	X	X
	Has knowledge about the types, possibilities and areas of application of programs and applications in the areas of architecture, construction, cost estimation, scheduling, installation design, etc.	X	X
	Knows the ranges of BIM models (3D, 4D, 5D, 6D, 7D).	X	X
	Knows what constitutes the information model.	X	X
	Knows the advantages of BIM in comparison to traditional project delivery.	X	X
	Understands the systematic concept of building information modelling.	X	X
	Knows about methods for cross-disciplinary coordination of models.	X	X
	Understands the benefits of minimizing costs at the design, construction and operation of a building due to the use of BIM.		X
	Has basic knowledge about parametric design.		X
Modelling 3D	Knows the BIM software.	X	X
	Knows how and what the BIM model can be used for.	X	X
	Knows different types of models and principles of work in BIM and level of detail (LOD).	X	X
	Knows what the IFC standard is and what its advantages and limitations are.	X	X
	Understands the hierarchy of objects in a model.	X	X
Calculations	Has knowledge about the principles of 3D model analysis, of the basic features of the building in terms of thermal and humidity issues.	X	X
	Has knowledge about the principles of 3D model analysis in terms of different kind of insulation.	X	X
	Knows the principles of 3D modelling of the structural system and applying loads in the building and carrying out structural analysis.	X	
Project time management	Knows theory for creating 4D simulation.	X	X
Costing	Knows the structure and the possibility of cost calculation using the BIM model.	X	X
	Has knowledge about the possibility of reducing costs and environmental parameters, increasing the ecology of construction and maintenance of the facility through the use of BIM.	X	X
Management	Knows how to use the BIM model on site and during operation of the building.		X
	Understands factors determining the level of BIM maturity in the organization.		X
Data management	Has knowledge how project and object data is defined, produced, exchanged and serviced.	X	X
	Understands the internal data structure and data hierarchy in an information model and in BIM objects.	X	X

	Knows what classification systems are for and how to use them in BIM models.	X	X
	Knows what effect the adoption of BIM technology has on the security of data.	X	X
	Knows what information is stored and what information can be extracted from the model.	X	X
	Understands the importance of using standards developed to mitigate unnecessary/poor information.	X	X
	Is aware of clearly defined roles of information management by individual participants of the design, construction and operation process based on BIM.		X
	Knows about levels of information (LOI) and understands principles for working with them.	X	X
	Knows standards and documented best-practice for managing level of information and for containing liabilities between disciplines.	X	X
	Understands principles of work sharing in a BIM environment.	X	X
Communication	Understands the advantages of frequent exchange of information in a BIM workflow.	X	X
	Knows the benefits of adopting BIM for investors, designers, contractors, facility managers in relation to communication.	X	X
	Can identify the key elements and advantages of using a common exchange platform.	X	X

5	Skills		
	-	DK	DE
BIM technology / philosophy	Can use work sharing tools for collaboration in one building information model.	X	X
	Can use parametric design in practise.		X
Documentation 2D	Can input drawings of documentation prepared using CAD as a background in 3D model.		X
	Can prepare the documentation needed for tender based on BIM technology.		X
Modelling 3D	Can read, create and edit BIM models in its industry (architecture, construction, installations, geodesy etc.)	X	X
	Can use the software tools interface.	X	X
	Can generate views, sheets, visualizations.	X	X
	Can import / export models from / to other programs, also using the IFC standard.	X	X
	Can extend and modify the BIM environment by creating new or modifying existing objects	X	X
	Is able to find and apply BIM objects with a LOI relevant to the project stage and the specific use	X	X
	Can share and exchange models.	X	X
Calculations	Can perform thermal and moisture calculations as well as energy efficiency analysis for a building model		X
	Can modify the material parameters and building figures in order to achieve the desired thermal and humidity parameters as well as insulation and solar energy use in a specific cross-disciplinary project context		X
	Can model construction systems in 3D and convert architectural models to analytical ones	X	X
Project time management	Can prepare drawings regarding particular phases of construction from the building model		X
	Can perform 4D simulation for a building object model		X
	Can use tools supporting planning in the BIM environment		X
	Can present the results of the time analysis and organization of the construction to the investor		X
	Is able to use BIM tools for modification of the schedule and for assessment of impact on the entire process in a specific project context		X
Costing	Can prepare a cost estimate using the data contained in the BIM model, allocate costs and set prices	X	X
Management	Is able to apply accounting, budgeting and booking principles in the area of construction to a model designed in the BIM environment		
Data management	Can develop objects in the information model to a required level of information.	X	X
	Can classify model elements using a coherent, recognized classification system.	X	X
	Can extract data to schedules.	X	X

	Can extract data for further processing and analysis in relevant programs.	X	X
	Can migrate processed data back into the model.	X	X
	Can use standards and apply best-practice to limit unnecessary information in the model	X	X
	Can manage and distribute rights of data handling in the model.		X
	Can properly select and modify the characteristics of construction materials.		X
Communication	Can exchange (import / export) BIM models with other participants in the design and construction process.	X	X

5	Responsibility and autonomy		
	-	DK	DE
BIM technology / philosophy	Is able to estimate a relevant degree of BIM implementation in a specific project, balancing effort and value achieved.		X
	Is aware of the need for continuous development of personal knowledge and skills in the field of BIM technologies.		X
	Understands that the BIM is a process which is strictly based on people, trust and communication.		X
	Understands the importance of concluding full data in the BIM model		X
	Is able to identify the need of model sharing and coordination in a multi-disciplinary project context		X
	Is able to set up exchange routines accordingly with a balanced consideration to time spent and value achieved		X
Costing	Is able to control and assess the quality of a BIM cost analysis	X	X
	Is able to apply 5D BIM tools and use them to include pricing as an active design parameter in a specific project context	X	X
Management	Is able to adjust BIM practice according to the BIM maturity of the specific organization		X
	Is able to set up a BIM execution plan to manage the process of using BIM in the entire construction project in a specific project context		X
Data management	Is able to identify and apply levels of information relevant to a given project context and stage of development	X	X
	Is able to identify and apply relevant data at suitable hierarchic levels in a model, relative to the intended use of data in a specific project context	X	X
	Is able to assess each participants need for data handling and data access during design, construction and operation stages in a specific project context		X
	Is able to manage of information in the model in a specific project context	X	X
	Is able to assess the consequences of poor model	X	X
Communication	Can work with people with different education.	X	X
	Understands the need to support open standards and interoperable solutions.	X	X
	Is able to collaborate with discipline to optimize efficiency and quality of collaborative production.	X	X

6TH LEVEL OF EDUCATION

6	Knowledge			
	-	DK	DE	PL
BIM technology / philosophy	Knows BIM terminology.	X	X	X
	Has knowledge about the types, possibilities and areas of application of programs and applications in the areas of architecture, construction, cost estimation, scheduling, installation design, etc.	X	X	X
	Knows the ranges of BIM models (3D, 4D, 5D, 6D, 7D).	X	X	X
	Knows what constitutes the information model.	X	X	X
	Knows the advantages of BIM in comparison to traditional project delivery.	X	X	X
	Understands the systematic concept of building information modelling.	X	X	X
	Knows about methods for cross-disciplinary coordination of models.	X	X	X
	Understands the benefits of minimizing costs at the design, construction and operation of a building due to the use of BIM.		X	X
	Has basic knowledge about parametric design.		X	X
	Has basic knowledge about programming language in parametric design.			X
	Knows that thanks to parametric design it is possible to optimize construction.			X
Documentation 2D	Knows the principles of preparing 2D documentation based on the 3D model.			X
Modelling 3D	Knows the BIM software.	X	X	X
	Knows how and what the BIM model can be used for.	X	X	x
	Knows different types of models and principles of work in BIM and level of detail (LOD).	X	X	X
	Knows what the IFC standard is and what its advantages and limitations are.	X	X	X
	Understands the hierarchy of objects in a model.	X	X	X
Calculations	Has knowledge about the principles of 3D model analysis, of the basic features of the building in terms of thermal and humidity issues.	X	X	X
	Has knowledge about the principles of 3D model analysis in terms of different kind of insulation.	X	X	X
	Knows the principles of 3D modelling of the structural system and applying loads in the building and carrying out structural analysis.	X	X	X
Project time management	Knows theory for creating 4D simulation.	X	X	X
Costing	Knows the structure and the possibility of cost calculation using the BIM model.	X	X	X
	Has knowledge about the possibility of reducing costs and environmental parameters, increasing the ecology of construction and maintenance of the facility through the use of BIM.	X	X	X
an ag em en	Knows how to use the BIM model on site and during operation of the building.	X	X	X

	Understands factors determining the level of BIM maturity in the organization.	X	X	X
Data management	Has knowledge how project and object data is defined, produced, exchanged and serviced.	X	X	X
	Understands the internal data structure and data hierarchy in an information model and in BIM objects.	X	X	X
	Knows what classification systems are for and how to use them in BIM models.	X	X	X
	Knows what effect the adoption of BIM technology has on the security of data.	X	X	X
	Knows what information is stored and what information can be extracted from the model.	X	X	X
	Understands the importance of using standards developed to mitigate unnecessary/poor information.	X	X	X
	Is aware of clearly defined roles of information management by individual participants of the design, construction and operation process based on BIM.	X	X	X
	Knows about levels of information (LOI) and understands principles for working with them.	X	X	X
	Knows standards and documented best-practice for managing level of information and for containing liabilities between disciplines.	X	X	X
	Understands principles of work sharing and distribution of rights and responsibilities in a BIM environment.	X	X	X
Communication	Understands the advantages of frequent exchange of information in a BIM workflow.	X	X	X
	Knows the benefits of adopting BIM for investors, designers, contractors, facility managers in relation to communication.	X	X	X
	Can identify the key elements and advantages of using a common exchange platform.	X	X	X

6	Skills			
	-	DK	DE	PL
BIM technology / philosophy	Can use work sharing tools for collaboration in one building information model.	X	X	X
	Can use parametric design in practise.		X	X
Document ation 2D	Can input drawings of documentation prepared using CAD as a background in 3D model.		X	X
	Can prepare the documentation needed for tender based on BIM technology.	X	X	X
Modelling 3D	Can read, create and edit BIM models in its industry (architecture, construction, installations, geodesy etc.)	X	X	X
	Can use the software tools interface.	X	X	X
	Can generate views, sheets, visualizations.	X	X	X
	Can import / export models from / to other programs, also using the IFC standard.	X	X	X
	Can extend and modify the BIM environment by creating new or modifying existing objects	X	X	X
	Is able to find and apply BIM objects with a LOI relevant to the project stage and the specific use	X	X	X
	Can share and exchange models.	X	X	X
Calculations	Can perform thermal and moisture calculations as well as energy efficiency analysis for a building model	X	X	X
	Can modify the material parameters and building figures in order to achieve the desired thermal and humidity parameters as well as insulation and solar energy use in a specific cross-disciplinary project context	X	X	X
	Can model construction systems in 3D and convert architectural models to analytical ones	X	X	X
	Can carry out structural analysis of various types of structures (steel, reinforced concrete, timber, wall and composite simulation).		X	X
	Is able to carry out quality and reliability checks on structural loads.		X	X
Project time management	Can prepare drawings regarding particular phases of construction from the building model	X	X	X
	Can perform 4D simulation for a building object model	X	X	X
	Can use tools supporting planning in the BIM environment	X	X	X
	Can present the results of the time analysis and organization of the construction to the investor	X	X	X
	Is able to use BIM tools for modification of the schedule and for assessment of impact on the entire process in a specific project context	X	X	X
Cost ing	Can prepare a cost estimate using the data contained in the BIM model, allocate costs and set prices	X	X	X

Management	Is able to apply accounting, budgeting and booking principles in the area of construction to a model designed in the BIM environment		X	X
Data management	Can develop objects in the information model to a required level of information.	X	X	X
	Can classify model elements using a coherent, recognized classification system.	X	X	X
	Can extract data to schedules.	X	X	X
	Can extract data for further processing and analysis in relevant programs.	X	X	X
	Can migrate processed data back into the model.	X	X	X
	Can use standards and apply best-practice to limit unnecessary information in the model and to contain liabilities	X	X	X
	Can manage and distribute rights of data handling in the model.	X	X	X
	Can properly select and modify the characteristics of construction materials.		X	X
Communication	Can exchange (import / export) BIM models with other participants in the design and construction process.	X	X	X
	Can prepare visualization.			X

6	Responsibility and autonomy			
	-	DK	DE	PL
BIM technology / philosophy	Is able to estimate a relevant degree of BIM implementation in a specific project, balancing effort and value achieved.	x	x	x
	Is aware of the need for continuous development of personal knowledge and skills in the field of BIM technologies.		x	x
	Understands that the BIM is a process which is strictly based on people, trust and communication.		x	x
	Understands the importance of concluding full data in the BIM model		x	x
	Is able to identify the need of model sharing and coordination in a multi-disciplinary project context	x	x	x
	Is able to set up exchange routines accordingly with a balanced consideration to time spent and value achieved	x	x	x
Calculations	Is able to cooperate with professionals from other disciplines to detect collisions and inconsistencies of the model		x	x
Costing	Is able to control and assess the quality of a BIM cost analysis	x	x	x
	Is able to apply 5D BIM tools and use them to include pricing as an active design parameter in a specific project context	x	x	x
Management	Is able to adjust BIM practice according to the BIM maturity of the specific organization	x	x	x
	Is able to set up a BIM execution plan to manage the process of using BIM in the entire construction project in a specific project context	x	x	x
Data management	Is able to identify and apply levels of information relevant to a given project context and stage of development	x	x	x
	Is able to identify and apply relevant data at suitable hierarchic levels in a model, relative to the intended use of data in a specific project context	x	x	x
	Is able to assess each participants need for data handling and data access during design, construction and operation stages in a specific project context	x	x	x
	Is able to manage of information in the model in a specific project context	x	x	x
	Is able to assess the consequences of poor model	x	x	x
Communication	Can work with people with different education.	x	x	x
	Understands the need to support open standards and interoperable solutions.	x	x	x
	Is able to collaborate with discipline to optimize efficiency and quality of collaborative production.	x	x	x

MATRIX OF BIM COMPETENCE FOR INDIVIDUAL EDUCATION LEVELS - PROPOSED COMPETENCES FOR TEACHING BIM

The competence matrix has been prepared for each level of education. The competences included in it can be chosen in whole or in a selected part - only the relevant decision making teams in individual schools / universities decides which competences will be selected. The division into educational levels is indicative and competences from another educational level can also be selected.
The competences for levels 3 and 4 and 5 and 6 overlap, so they are presented in the common tables.

BIM technology / philosophy

Calculations

Management

Documentation 2D

Project time management

Data management

Modeling 3D

Costing

Communication

LEVEL 3 AND 4 OF EDUCATION

Level 3 is designed for vocational training in lower vocational schools: roofer (PL), building and finishing fitter (PL), construction worker (DE), support worker (DE).
Level 4 is designed for vocational training in upper secondary vocational schools or technical colleges: building technician (PL), building and finishing technician (PL), draftsman (DE, BE, DK), concrete fitter, armourer (DE), mason (DE, DK), carpenter (DE, BE, DK).
Schools involved in preparing the matrix: RSI (Belgium), ZAWM (Belgium), Aarhus Tech (Denmark), MBS and OSZBau (Germany), ZSB (Poland).

Symbol	KNOWLEDGE		3	4
K1		Knows a software/an app for handling a BIM-Project on a construction site		
K2		Knows the working methodology of Building Information Modeling. (3D, 4D, 5D, collision control, interdisciplinary cooperation ...)		
K3		Knows a constructional Project, which can be transformed in a BIM-structure.		
K4		Knows ways to extract information from a data model.		
K5		Know the coordination structure of a BIM project.		
K6		Knows different digital documentation devices and their fields of application.		
K7		Has knowledge of the connection structure between digital documentation instruments.		
K8		Has knowledge of connecting digital documentation instruments with digital terminals / knowledge of storage and dispatch options.		
K9		Knows different digital communication devices and their fields of application.		
K10		Is familiar with different digital measuring and documentation devices and their application areas application.		
K11		Has knowledge of operating digital measurement and documentation tools.		
K12		Has knowledge of how to connect digital measurement and documentation instruments to digital devices / to enter data into digital devices.		
K13		Knows formats for saving in the required manner, export.		
K14		Has knowledge about the layer structure. Knows the basics off digital drawings, according to national standard. Knows the devices and their application areas application.		
K15		Has knowledge about the layer structure when drawing up relevant work drawings.		
K16		Knows how to distinguish types of cost estimates, inputs, labor, materials, equipment.		

K17		Knows the characteristic elements included in the cost estimates.		
K18		Has knowledge about commands for creating and modifying a project file		
K19		Has knowledge about commands for modelling of existing construction components (library, database)		
K20		Has knowledge about commands to modify the construction components (position, attributs, level, …)		
K21		Has knowledge about bim objects in external database/libraries		
K22		Has knowledge about graphical commands		
K23		Has knowledge about dimensioning and labeling		
K24		Has knowledge about layout functions and scale settings		
K25		Has knowledge about printing and exporting (PDF) a plan		
K26		Knows how to insert moving camera; Knows how to edit the camera; Knows how to adjust camera settings		
K27		Knows how to set up fixed and moving light sources		
K28		Knows how to render images based on his own image quality		
K29		Knows how to insert and set a fixed camera position		
K30		Has knowledge how to distinguish types of cost estimates, inputs, labor, materials, equipment		
K31		Knows what is the difference between computer programs for making cost estimates		
K32		Has knowledge how to provide a component with information		
K33		Has knowledge about the use of communication platforms within the program		
K34		Has knowledge of exporting data models		
K35		Has knowledge how to import external data models from other disciplines		

Symbol	SKILLS		3	4
S1		Can structure a constructional Project with a BIM-software/app,…; (Can create a functional BIM structure for a construction project using a software / app, define responsibilities, assign access and editing rights, read out component information, create checklists, edit checklists, communicate with other parties.)		
S2		Can explain the BIM method in the context of her professional activity.		
S3		Can select suitable digital devices for creating the digital documentation.		
S4		Can establishing a connection between digital devices.		
S5		Can store and transfer of ascertained data.		
S6		Can select and operate suitable communication devices.		
S7		Can select suitable digital devices for recording the planning measures / planning information.		
S8		Can use digital surveying and documentation tools.		
S9		Can transmit the determined data to a digital terminal.		
S10		Can export the data in suitable form for further use.		
S11		Can use an electronic-based drawing program to create 2D object-based floor plans in various levels of detail according to standard drawing requirements.		
S12		Can use the BIPS layer structure to measure floor plans and apply text.		
S13		Can create and edit their own plan, cut and draw patterns, and move from drawing to drawing.		
S14		Can use a CAD program to create simple working drawings with plan- and page images.		
S15		Is familiar with drawing and using views.		

S16		Can use the geometry capabilities of CAD programs as well as editing and manipulation tools.		
S17		Is aware of the legal structures and can apply them according to the building standards.		
S18		Can use IT items.		
S19		Can complete cross-sections and facades from finished 3D object-based floor plans.		
S20		Can create new 3D CAD drawings, thus contributing constructive and relevant suggestions to current ones constructs.		
S21		Can handle and apply 3D CAD drawings in conjunction with the construction process, according to national standard.		
S22		Can read the catalog of material inputs.		
S23		Can explain the principles of making cost estimates, that is, the technique of making.		
S24		Can determine the output data for cost estimates.		
S25		Can read documentation, specifications.		
S26		Can read the essential conditions for the acceptance of works.		
S27		Can use and modify a template.		
S28		Can model the different construction components		
S29		Can modify the construction components		
S30		Can import bim objects		
S31		Can use the graphical commands		

S32		Can dimension and label the view.		
S33		Can create layouts and plans in 2D		
S34		Can print and export a plan		
S35		Can produce visualizations with different lighting phrases with the use of 3D software: Daylight, Friendly lighting outside, Favorite lighting inside		
S36		Can set up set / adjust fixed light source: Light lights inside, Stand lights inside, Light under the suspension, Lighting in driveway, Course list / interim goals (continued)		
S37		Can conduct light study based on the sun's movement during one day (shadow effect on property / property): Solar Study, Sun Parth		
S38		Can create images, rendering, showing your building from and to each room: Photos from different positions and different heights outside, Photos of each room, Photos of different quality, Photos with different lighting		
S39		Can make a simple animation, walkthrough, which shows the building exterior / inside: Overall height levels / camera angle adjustment outside, Image inside the building / camera height / angle adjustment		
S40		Can apply computer techniques in the preparation of cost estimates		
S41		Can comment a component with aChange cloud / ID data		
S42		Can use an internal programcommunication platform for data andinformation exchange		
S43		Can export the data model via IFC, DWG, DXF, PDF		
S44		Can import data models of different disciplines into the overall model		

symbol	RESPONSIBILITY AND AUTONOMY		3	4
C1		Is able to communicate in the terms of the software/app.		
C2		Is aware that he carry out digital documentation on their own responsibility. Knows how to communicate with the in-house hierarchy.		
C3		Is aware that he is self-responsible for an oversize and that he should pay attention to the construction site safety. Knows how to communicate with the participants regarding specific requirements. Knows how to communicate with the in-house hierarchy.		
C4		Is able to apply the principles of personal culture		
C5		Is able to apply the rules of professional ethics		
C6		Is able to analyze jointly the changes taking place in the industry in the field of calculation		
C7		Is able to take new calculation challenges		
C8		Is able to be open to the use of new methods and work techniques		
C9		Is able to work in a small and large calculation team		
C10		Is able to accept readiness for continuous learning and professional development in the team		
C11		Is able to use different sources of information to improve professional skills		
C12		The school is able to has a close cooperation with the business community in developing and planning courses and courses (the interaction creates the best quality in education and training)		
C13		The school has a culture of learning that focuses on high professionalism (everyone wins by focusing on empowerment of the individual)		
C14		The school has a learning culture, where recognition is a bearing principle (a recognizable approach both supports the development of the individual and provides space for diversity)		
C15		The teaching is based on the individual and builds on his / her professional and personal skills, individual wishes and opportunities, as well as prepares the individual for business or further education (differentiation creates motivation and challenges the individual's learning and development)		
C16		The teaching is organized so that there is a link between theory and practice (the link gives concrete skills and a holistic understanding of the reality that the individual is acting in)		
C17		The teaching is planned and evaluated in dialogue with the students, the students or the course participants (dialogue supports co-responsibility for self-learning and learning in interaction with others)		
C18		Is able to be open to the use of new methods and work techniques		

LEVEL 5 AND 6 OF EDUCATION

Level 5 is defined for technical and upper secondary education: building techniques (DK).
Level 6 is determined for technical education and higher vocational schools and first cycle engineering studies: civil engineer (PL, DE), architect (PL), architect (DK), architectural technology and construction management engineer (DK).
Schools involved in preparing the matrix: VIA UC (Denmark), HTW (Germany), PP (Poland).

Symbol	KNOWLEDGE		5	6
K36		Knows BIM terminology.		
K37		Has knowledge about the types, possibilities and areas of application of programs and applications in the areas of architecture, construction, cost estimation, scheduling, installation design, etc.		
K38		Knows the ranges of BIM models (3D, 4D, 5D, 6D, 7D).		
K39		Knows what constitutes the information model.		
K40		Knows the advantages of BIM in comparison to traditional project delivery.		
K41		Understands the systematic concept of building information modelling.		
K42		Knows about methods for cross-disciplinary coordination of models.		
K43		Understands the benefits of minimizing costs at the design, construction and operation of a building due to the use of BIM.		
K44		Has basic knowledge about parametric design.		
K45		Knows the BIM software.		
K46		Knows how and what the BIM model can be used for.		
K47		Knows different types of models and principles of work in BIM and level of detail (LOD).		
K48		Knows what the IFC standard is and what its advantages and limitations are.		
K49		Understands the hierarchy of objects in a model.		
K50		Has knowledge about the principles of 3D model analysis, of the basic features of the building in terms of thermal and humidity issues.		
K51		Has knowledge about the principles of 3D model analysis in terms of different kind of insulation.		
K52		Knows the principles of 3D modelling of the structural system and applying loads in the building and carrying out structural analysis.		

K53		Knows theory for creating 4D simulation.		
K54		Knows the structure and the possibility of cost calculation using the BIM model.		
K55		Has knowledge about the possibility of reducing costs and environmental parameters, increasing the ecology of construction and maintenance of the facility through the use of BIM.		
K56		Knows how to use the BIM model on site and during operation of the building.		
K57		Understands factors determining the level of BIM maturity in the organization.		
K58		Has knowledge how project and object data is defined, produced, exchanged and serviced.		
K59		Understands the internal data structure and data hierarchy in an information model and in BIM objects.		
K60		Knows what classification systems are for and how to use them in BIM models.		
K61		Knows what effect the adoption of BIM technology has on the security of data.		
K62		Knows what information is stored and what information can be extracted from the model.		
K63		Understands the importance of using standards developed to mitigate unnecessary/poor information.		
K64		Is aware of clearly defined roles of information management by individual participants of the design, construction and operation process based on BIM.		
K65		Knows about levels of information (LOI) and understands principles for working with them.		
K66		Knows standards and documented best-practice for managing level of information and for containing liabilities between disciplines.		
K67		Understands principles of work sharing in a BIM environment.		
K68		Understands the advantages of frequent exchange of information in a BIM workflow.		
K69		Knows the benefits of adopting BIM for investors, designers, contractors, facility managers in relation to communication.		
K70		Can identify the key elements and advantages of using a common exchange platform.		
K71		Knows the principles of preparing 2D documentation based on the 3D model.		
K72		Has basic knowledge about programming language in parametric design.		
K73		Knows that thanks to parametric design it is possible to optimize construction.		
K74		Understands principles of distribution of rights and responsibilities in a BIM environment.		

Symbol	SKILLS		5	6
S45		Can use work sharing tools for collaboration in one building information model.		
S46		Can use parametric design in practise.		
S47		Can input drawings of documentation prepared using CAD as a background in 3D model.		
S48		Can prepare the documentation needed for tender based on BIM technology.		
S49		Can read, create and edit BIM models in its industry (architecture, construction, installations, geodesy etc.)		
S50		Can use the software tools interface.		
S51		Can generate views, sheets, visualizations.		
S52		Can import / export models from / to other programs, also using the IFC standard.		
S53		Can extend and modify the BIM environment by creating new or modifying existing objects		
S54		Is able to find and apply BIM objects with a LOI relevant to the project stage and the specific use		
S55		Can share and exchange models.		
S56		Can modify the material parameters and building figures in order to achieve the desired thermal and humidity parameters as well as insulation and solar energy use in a specific cross-disciplinary project context		
S57		Can prepare drawings regarding particular phases of construction from the building model		
S58		Can use tools supporting planning in the BIM environment		
S59		Can prepare a cost estimate using the data contained in the BIM model, allocate costs and set prices		
S60		Can develop objects in the information model to a required level of information.		
S61		Can classify model elements using a coherent, recognized classification system.		
S62		Can extract data to schedules.		
S63		Can extract data for further processing and analysis in relevant programs.		
S64		Can migrate processed data back into the model.		
S65		Can use standards and apply best-practice to limit unnecessary information in the model		

S66		Can manage and distribute rights of data handling in the model.		
S67		Can properly select and modify the characteristics of construction materials.		
S68		Can exchange (import / export) BIM models with other participants in the design and construction process.		
S69		Can perform thermal and moisture calculations as well as energy efficiency analysis for a building model		
S70		Can model construction systems in 3D and convert architectural models to analytical ones		
S71		Can perform 4D simulation for a building object model		
S72		Can present the results of the time analysis and organization of the construction to the investor		
S73		Is able to use BIM tools for modification of the schedule and for assessment of impact on the entire process in a specific project context		
S74		Is able to apply accounting, budgeting and booking principles in the area of construction to a model designed in the BIM environment		
S75		Can use standards and apply best-practice to contain liabilities		
S76		Can carry out structural analysis of various types of structures (steel, reinforced concrete, timber, wall and composite simulation).		
S77		Is able to carry out quality and reliability checks on structural loads.		
S78		Can prepare visualization.		

Symbol	RESPONSIBILITY AND AUTONOMY		5	6
C19		Is able to estimate a relevant degree of BIM implementation in a specific project, balancing effort and value achieved.		
C20		Is aware of the need for continuous development of personal knowledge and skills in the field of BIM technologies.		
C21		Understands that the BIM is a process which is strictly based on people, trust and communication.		
C22		Understands the importance of concluding full/selected data in the BIM model		
C23		Is able to identify the need of model sharing and coordination in a multi-disciplinary project context		
C24		Is able to set up exchange routines accordingly with a balanced consideration to time spent and value achieved		
C25		Is able to control and assess the quality of a BIM cost analysis		
C26		Is able to apply 5D BIM tools and use them to include pricing as an active design parameter in a specific project context		
C27		Is able to adjust BIM practice according to the BIM maturity of the specific organization		
C28		Is able to set up a BIM execution plan to manage the process of using BIM in the entire construction project in a specific project context		
C29		Is able to identify and apply levels of information relevant to a given project context and stage of development		
C30		Is able to identify and apply relevant data at suitable hierarchic levels in a model, relative to the intended use of data in a specific project context		
C31		Is able to assess each participants need for data handling and data access during design, construction and operation stages in a specific project context		
C32		Is able to manage of information in the model in a specific project context		
C33		Is able to assess the consequences of poor model		
C34		Can work with people with different education.		
C35		Understands the need to support open standards and interoperable solutions.		
C36		Is able to collaborate with discipline to optimize efficiency and quality of collaborative production.		
C37		Is able to cooperate with professionals from other disciplines to detect collisions and inconsistencies of the model		

CONCLUSIONS

The possibility of introducing BIM teaching at different stages of education depends on external factors at national level (introduction of BIM standards and legal regulations) and internal factors depending on the type of schools. The key factor is the willingness of teachers to improve their competences and to change the teaching system from traditional to modern technologies. It entails the need to invest not only in hardware and software, but above all in training for teachers and lecturers. The role of countries should be to support initiatives to increase the level of digitisation in their countries. Striving to implement these tasks will result in an increase in the level of development of the IT infrastructure of educational institutions, which in turn will contribute to updating the educational offer.

The development of guidelines for teaching new BIM-related competences is a very important issue and requires a lot of discussion with both teachers and practitioners who are familiar with the relevant aspects of the field. The knowledge and experience of countries where the new technology has already been implemented is a great support, but there are always local political and economic conditions that can speed up or delay the implementation process.

Training the young generation, for whom digitisation is not a problem, is much easier. In addition, these people are at the stage of acquiring education and their motivation seems to be greater. However, it should also be remembered that there are definitely more people who have been working in the construction professions for many years and who have found the change of work system to BIM at a later age. As a result, they have much less time to spend on additional training. It is necessary to plan trainings for this group of people as well.

A separate aspect is the issue of providing the hardware and software necessary to apply BIM technology, the lack of which is a very important factor inhibiting the implementation of the changes in question, especially for small companies. All these aspects should be kept in mind when planning future legal changes, but today the greatest effort should be made to complement the teaching of the profession with digital competences, as educated staff will in the future be a lasting basis for the effective implementation of the new, necessary technology which is undoubtedly BIM.

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