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PREREQUISITES FOR BUILDING AN INNOVATIVE ONLINE PLATFORM SUPPORTING BIM IMPLEMENTATION IN HIGHER EDUCATION

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Abstract
The aim of the paper is to present outcomes of the first phase of the ongoing EU-funded Project BIMaHEAD focused on building digital readiness in higher education institutions as well as supporting students in AEC related degrees to adjust to the new online education environment caused by the COVID-19 pandemic through integrating digital technologies with teaching and learning practices. An in-depth comparative analysis of 132 case studies focused on Building Information Modelling education in a Higher Education sector in Europe was completed and conclusions were drawn. A great amount of data was collected, studied, and analysed. The benchmarking analyses were fundamental for understanding the state of the art in the area, defining gaps and deficiencies, and rethinking teaching and learning methodologies. The findings also revealed evident differences in curricula as well as in the roles and responsibilities of main actors in the AEC sector in European countries. Therefore, they allowed to specify prerequisites and outline a vision of an open-access online platform to be developed within the second and third stages of the BIMaHEAD Project.

Keywords: **BIM; Building Information Modelling; e-learning; Higher Education survey; HE benchmark analysis.**

1. INTRODUCTION

There have been over two years since higher education institutions were closed and switched to online mode of teaching and working due to the global pandemic situation. After these two years, it is evident how strongly the sudden global lockdown has influenced the way people communicate, work and study.

During the first year of the global pandemic, it was the very moment when the question of delivering high-quality teaching took on a new meaning. This issue became particularly important in architecture domain where the tradition and culture of education had been enrooted in a master-apprentice model and face-to-face tutoring. It was evident that in early spring 2020 the situation changed dramatically and called for rapid and efficient solutions. In the first months, uncertainty was undoubtedly one of the factors associated with the process. Therefore, an international group of researchers from France, Germany, North Macedonia, Poland and Sweden focusing on the Architecture, Engineering and Construction sector (AEC) prepared a proposal for a project and submitted it under the Strategic Partnerships Erasmus+ Programme of the European Union to elaborate on new ways how to support academic education in the Building Information Modelling area to meet future technological tendencies in professional work [1, 2].

Undeniably, BIM is becoming an integral part of the needed and expected qualifications of workers in the AEC sector [3, 4]. What is more, it has been adopted as a standard on governmental level in some countries already, and the list of countries is growing. Additionally, the increasing requirement of BIM in public procurements is observed. So, it is time for the shift in educational programmes aiming at subject spe-

cific digital skills for the future professionals in the construction related industry [5, 6]. Due to the scope of the EU Project, and the expected beneficiaries of the results, the context and perspective of European countries have been considered [7].

2. PROJECT DESCRIPTION

The BIMaHEAD acronym stands for Building dIgital coMpetencies of students and teacHers in construction related degrees & increasing digital reaDiness of EU universities. The aim of the Project is to support building digital readiness in higher education institutions and to support students in AEC related degrees to adjust to the new online education environment created by the COVID-19 pandemic through integrating digital technologies with teaching and learning practices. The main goal of the Project is to design, test and implement an innovative online platform for self-motivated independent learners seeking to acquire knowledge and skills in Building Information Modelling. Thus, the target groups are: students and academic staff in Higher Education Institutions (HEIs).

The Project activities started with brainstorming and discussion to define a list of countries that would be taken for benchmarking analysis of existing programmes and courses in BIM in Higher Education (HE) in Europe. The aim of this task was to collect as much data and information as possible in the given time. There was no limited list of target universities/institution pre-defined. The idea was to search as vast as possible all the curricula offered in the disciplines educating for AEC sector. However, some limitations occurred due to many lockdowns all over Europe that disabled personal or even online, but still direct contact with HE institutions. Therefore, it was agreed that apart from research in each participant country, the study would be conducted in the form of online sources desk research, thus the criteria of eliminating the language barrier appeared crucial. The parallel criteria was to collect a rich variety of knowledge, so the partners effort was to pick countries meeting all these conditions. As a result, the following list of European countries was prepared: Austria, Belgium, Bosnia and Herzegovina, Denmark, Finland, France, Germany, Ireland, North Macedonia, Poland, Sweden. Then, a preselection of case studies from each country was proposed. Due to many lockdowns all over Europe, there was a real challenge to collect detailed data about courses, such as content and structure, duration of programmes, modules description, teaching methods, and learning outcomes. Finally, 132 case studies were completed. Such a comprehensive data sheet allowed to specify best practices but also to identify shortcomings.

3. RESEARCH METHODOLOGY AND TOOLS

Prior to case studies collection, the very first activity in the Project aimed to create a research methodology and related tools to harmonize the work of data and resources collection and analysis. The specific tasks were defined as follows:

- overall methodology description and justification;
- tools for collecting data – desk research (templates for data collection);
- methodology for analysis.

Regarding sampling methodology, the data was collected by means of non-probability sampling. Non-probability sampling is carried out by methods of observation and is widely used in qualitative research. This is a sampling technique in which a researcher selects samples based on his/her subjective judgment rather than random selection. In non-probability sampling, not all members of population have a chance of participating in the study. It is useful for exploratory studies, where sampling needs a less rigorous method [8].

A desk research method was chosen as a research technique to collect data from existing resources. This method is very effective in a starting phase of market research as it is fairly quick and relatively inexpensive, and, moreover, most of the basic information can be easily gathered which may be used as benchmark in the research process [9]. To register collected data efficiently, special templates in MS Word and MS Excel were created.

As it has been mentioned in the paper already, benchmarking was used as a method for analysis. According to Camp, benchmarking is defined as "the search for the best industry practices which will lead to exceptional performance through the implementation of these best practices" [10]. According to the Quality Assurance Agency for Higher Education in the UK (QAA), benchmarking is part of a larger infrastructure for the assurance of academic standards that is intended to provide the basis for strengthening, elaborating and making more comprehensible the purposes and outcomes of higher education [11].

The following parameters were selected for the analysis of the findings focusing on pedagogical dimension:

- Content and structure: BIM fundamentals (princi-

ples of workflow and collaboration in digital environment), Basic terms and definitions associated with BIM, BIM 3D Modelling, Scheduling in BIM (BIM 4D), Quantities and costs (BIM 5D), Sustainability and BIM (6D), Energy performance of buildings supported by BIM;

- Duration of programs: < 100 hours, 100 ≤ hours < 500, 500 ≤ hours < 1000, >1000 hours;
- Teaching methods: classroom, distance, online, blended;
- Best practises.

The main objective was integrating all analysis and benchmarking reports by means of a template of results, so a specific MS Excel template was also designed to make comparison between countries, permitting to establish conclusions and recommendations for developing learning materials in the frame of the BIMaHEAD Project.

4. RESEARCH OUTCOMES

The scope of the analysis included 132 courses/programmes in 11 European countries. The distribution of the courses per country has performed as follows:

Austria – 7
Belgium – 8
Bosnia and Herzegovina – 7
Denmark – 4
Finland – 5
France – 47
Germany – 13
Ireland – 11
North Macedonia – 10
Poland – 13
Sweden - 7

Different parameters were selected for the analysis of programmes/courses in BIM, viz.: content and structure, duration of programmes and teaching methods.

Table 1 presents the number of BIM courses in each country reflecting the content. What can be observed is the first two BIM topics that are of the basic nature have been well covered in the analysed programmes. The dramatic drop in the number of courses is visible when it considers advanced BIM, starting with BIM 4D, 5D, etc. The lowest number of courses and from the lowest number of countries (five only) incorporate the topic of Sustainability and BIM. This topic is represented in the samples from the following countries: Austria, Bosnia and Herzegovina, France, Ireland, and Poland. What is more, in the analysed samples the topic dominates only in Ireland. On the contrary, Denmark is the country where none of the analysed programmes cover BIM 3D Modelling or more advanced topics such as BIM 4D, BIM 5D, BIM 6D or energy performance of buildings supported by BIM. Another observation is that the number of courses per country does not literary reflect the number of courses per category since majority of analysed courses did not fit fully in a single category, on the contrary, most of them covered more than one category, however, not entirely.

Table 1.
A summary presenting the number of courses fitting each category in the analysed countries

List of countries:	BIM Indicator:						
	BIM fundamentals (principles of workflow and collaboration in digital environment)	Basic terms and definitions associated with BIM	BIM 3D Modelling	Scheduling in BIM (BIM 4D)	Quantities and costs (BIM 5D)	Sustainability and BIM (6D)	Energy performance of buildings supported by BIM
Austria	3	4	3	2	2	1	-
Belgium	7	7	5	3	2	-	1
Bosnia and Herzegovina	7	7	2	2	2	1	3
Denmark	4	4	-	-	-	-	-
Finland	5	5	2	-	-	-	-
France	40	40	37	6	4	2	7
Germany	8	2	10	1	1	-	-
Ireland	11	11	9	8	3	6	7
North Macedonia	10	10	2	-	-	-	7
Poland	13	13	13	4	5	4	4
Sweden	7	7	3	-	-	-	-
Number of courses in total:	115	110	86	26	19	14	29

Source: Author's own elaboration based on the 1st phase of the BIMaHEAD Project.

Concerning the duration of the courses, the analysis covered diverse programmes which lasted from less than 100 hours to more than 1000 hours. The percentage values of BIM courses in each country reflecting the duration of programmes have been compared. The study reveals the most popular are the courses that last less than 100 hours and those lasting between 100 and 500 hours, and such mixture is visible in six countries. It is rarely to find the course that takes more than 1000 hours. Such examples have been found in Ireland. All courses in Denmark occupy between 100 and 500 hours while 100% of courses in Bosnia and Herzegovina last less than 100 hours.

The next parameter that was taken into consideration was the teaching methods. Four methods were considered: blended, distance, online and classroom. The key assumption was to focus on pre-pandemic period in this regard since during pandemic time almost all courses were either altered or cancelled or provided online, even though many of them had not been prepared for such teaching mode. The results show that in Sweden there is an even distribution of the analysed teaching methods between classroom, blended and online learning. In Poland 15% of the programmes/courses were held through distance learning, however the most popular was classroom type. In North Macedonia, 60% of the analysed courses were held online and 40% were blended. In Ireland, 64% of the courses were held in classroom, 27% were provided online, and 9% were held with blended learning. In Germany 54% of the programs/courses were held online, while 8% were held in classroom and with blended learning respectively. For some courses there was no data available. In France and Belgium 100% of the BIM courses were held in a classroom. In Finland most of the programs/courses were provided in classroom (80%), while also combining blended and online learning. In Bosnia and Herzegovina 57% of the courses were held in a classroom, while 43% were held with blended learning. In Austria 43% of the analysed programmes were provided in a classroom, 29% were held with distance learning, while 14% were held with blended learning and online learning respectively.

There were interesting findings during the process of data collection and evaluation. For example, in Bosnia and Herzegovina as well as in North Macedonia there are no BIM courses in HE curricula at all. Therefore, most of the analysed programmes/courses are offered outside of HEIs and are targeting professionals. These courses are held by Vocational education and training institutions (VET), companies or consultants. So, students have to seek alternative courses to gain required knowledge and skills. What the working group also discovered was the differences in the role and responsibilities of architects in the investigated countries. It directly influences curricula and may occur a reason of their evident dissimilarities.

Regarding best practices, in Ireland some programmes offer certificates or degrees in BIM, some have accreditation on national level. Best practices for BIM training in Poland are trainings and postgraduate courses dedicated to practicing engineers and architects. They allow improving the professional competencies of people currently working as architects and constructors and orient them to work in a digital BIM environment. The learners are awarded certificates. In Germany, the University in Bochum stands out due to its interdisciplinarity and the inclusion of structural calculations. And for Austria, a high BIM level is taught at TU Wien, many programs are used (Revit, ArchiCAD, Dlubal, REFM, Grasshopper, Karamba 3D, Solibri), and students work together with other disciplines on an interdisciplinary basis. Among other things, the calculation of the supporting structure, energy and sustainability, technical building equipment, building physics are taught there, as well as certification via the German Sustainable Building Council (DGNB) is provided.

5. CONCLUSIONS

The first phase of the BIMaHEAD Project focused on defining prerequisites for building an innovative online platform supporting BIM implementation in higher education. As it was mentioned earlier, the working group discovered differences in the role and responsibilities of architects and engineers of AEC sector in the investigated countries. Since architects and engineers receive their education in HEIs, the curricula reflect expected professional profiles directly. Thus, it may be a reason of their evident dissimilarities what makes the Project even more challenging.

Regarding pedagogical scenarios the universities at large use conventional teaching methods, like lectures, seminars, project group work, written exams, workshops, tutorials. Moreover, there was no pedagogical method found at the survey phase that the Partners would indicate as innovative. As a result of the first stage of the Project, some preliminary features of the BIMaHEAD course were specified. In general, designed online BIM courses should fit the level of knowledge and be addressed to specific

groups (ex.: undergraduate students, postgraduate students, practitioners). In the contrast to existing offer, they should not be linear but should allow to choose self-learning pathways. Moreover, they should enable a learner to achieve certain levels proofed by certificates. As for the innovative pedagogy planned in the BIMaHEAD Project, that would respond to the Z generation needs (as the main addressee of the Project), the structure of the courses is planned to be based on gamification methodology and involve VR technology. This topic belongs to the next phase of the Project and the work is in progress.

To conclude with the final reflection, the new working environment caused by many lockdowns and isolation seemed temporary. On the one hand, it is believed that as soon as the pandemic is over academia will come back to a normal way of providing education and research. This has already been observed in countries that have announced the end of the pandemic. On the other hand, it is more and more questionable what "normal" means actually after such a long time of isolation. Therefore, the learning tool we are proposing under the BIMaHEAD Project aims to be suitable not only for the pandemic situation but for "new normality" as well.

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