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BIM training in construction management educational practices in Croatia and Slovakia

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Abstract

Building Information Modeling (BIM) is an intelligent 3D model-based process that enhances productivity and management performance of construction projects. For its successful adaptation, education and standardization are one of the prerequisites and key success factors. Even though some countries in the European Union have started to mandate the usage of BIM on all public projects and have developed standards to support such implementation, Croatia and Slovakia have done little to support such initiatives. Furthermore, to support BIM usage, universities need to update their curricula accordingly and thus enable construction engineers the knowledge and skills. This would lead to new BIM competencies. In order to understand the current status quo of the BIM education provided in Croatia and Slovakia, map the reasons of scarce BIM initiatives and propose guidelines for improvements, we surveyed and compared two representative civil engineering faculties which are Faculty of Civil Engineering Košice and Faculty of Civil Engineering Zagreb. The survey investigated Construction Management program on master study and assessed achievement of each BIM learning outcomes. The results show that very little has been done in integration of different knowledge areas towards open BIM approach. This is especially evident in the knowledge areas such as coordination, interoperability and clash detection. Hence, some rare courses which include BIM are being taught independently of each other and could be set to BIM level 1 maturity level. At the end of the paper we provide guidelines for improvement of undergraduate and graduate studies.

Keywords: building information modeling; construction management; Croatia; education; Slovakia.

1. Introduction

Building Information Modeling (BIM) is an intelligent 3D model-based process that enhances productivity and management performance of construction projects. Implementation of BIM is steadily gaining popularity in construction industry and as such BIM knowledge represents important learning outcome in higher students' education. Moreover, to increase the BIM application, authors suggested several strategies where providing BIM education at university level is one of them [1]. Even though BIM shows promising results and is the current trend in the construction industry, and many countries are obliged to use it, education of construction engineers (pedagogy, curricula, learning outcomes etc.) still has not caught up with the trends [2]. Reasons for absence of BIM in the curricula of civil engineering practices can be found in inadequate and not educated staff, inadequate resources and support to make the curriculum changes and the fact that there is no space left within curriculum [3, 4, 5, 6, 7, 8]. As a result, the industry suffers from insufficient educated employees [9]. Furthermore, BIM education at universities is often directed to software training which is not enough for deeper understanding of BIM concept and development of BIM skills [4, 10]. Besides, researchers [4, 5, 7] recommended to create a plan for BIM integration into Architects, Engineering and Construction (AEC) curricula and to define basic BIM knowledge areas important for future civil engineers. These

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actions will help in creating awareness for BIM implementation in higher education [5, 6, 11]. Introducing of BIM in education should start as soon as possible, so it is recommended within undergraduate study. Current and better technologies should be presented to students before they start to learn old and not so useful technology. Thus, vertical integration of BIM education is very important for spreading complexity of problems so BIM education should be part of undergraduate, graduate and postgraduate study [5, 6]. This trend will increase the percentage of BIM usage among students as well as practitioners [5, 6].

Problem connected with BIM education within Construction Management (CM) field is to define learning outcomes, curriculum of courses and specific knowledge which is necessary for future construction and project managers. Sacks and Pikas classified BIM competency topics which are necessary to realize through the first or master degree level of CM program in three categories: BIM-related general knowledge area and processes (12 topics), BIM technology (10 topics) and BIM applications/ functionalities (17 topics) [12, 13]. Moreover, CM education should start with the first phase of creating a new model. If students did not complete 3D model, they would not develop needed skills of spatial visualization which is very important to understand how processes of material procurement, cost estimation and scheduling work together, but also how to accomplish their integration [14, 15]. Additionally, Kim found the following objectives of CM education: evolve student's skills, ability and construction knowledge to develop appropriate levels of cost estimates; evolve communication skills and ability to function in multidisciplinary teams [16]. Nevertheless, processes of comparing the architectural, structural and services models, for coordination and clash detection, is proven to be a necessary step in understanding collaboration and interoperability [14, 15, 17]. In majority higher educational programs integration and collaboration between disciplines have not been achieved yet. Therefore, BIM education is often part of separated departments and disciplines with minimal trust between project participants [5, 18] and in such environment is hardly to expect encouraging information integrity and collaboration. Thus, horizontal integration of BIM education is necessary [6]. Besides, BIM learning outcomes could be reached thought single-course (when BIM is introduced only to one discipline), interdisciplinary collaboration (when students are learning BIM concepts through two or more disciplines within one university), distance collaboration (when students learn real BIM collaboration with students from two or more distance universities and driplines), BIM capstone courses or project and multinational academic experience [10, 19].

Larger companies with more employees find BIM in constructability and visualization to contribute the most to the success of their projects. Thus, these companies need employees with two conceptual roles Design-Build and Construction Managers with BIM knowledge [20] to enable latest project delivery [21]. Furthermore, Uhm et al. identified eight BIM job types which included BIM project manager, director, BIM manager, BIM coordinator, BIM designer, senior architect, BIM MEP coordinator and BIM technician but also identified BIM competencies for each BIM job group [22]. They classified BIM competencies into groups which are essential (required for all BIM job groups), common (required for a majority of job groups) and job-specific competencies (required by some BIM job groups) [22]. Research by Uhm et al. provides roadmap for becoming an expert in each role as well as it could be good start point when defining BIM education and training for students in higher education and employees in construction companies [22]. Moreover, BIM professions BIM manager/engineer and BIM project manager are the most common professions connected with BIM. According to Wang and Leite BIM manager/engineer is required to understand what BIM is and how it changes the work process, have abilities to create BIM models, to perform data analysis with existing BIM models, to use BIM visualization and communication tools but also have experience in working with specific BIM tools. In comparison with BIM manager, BIM project manager may or may not directly use BIM, but has to understand what BIM is and how it changes the work processes, should have abilities to use BIM as a visualization and communication tolls but also to perform data analysis whit existing BIM models [2]. Rahman et al. identified BIM skills which are 'BIM', 'Revit', 'CAD', '3D', 'steel detailing', 'Navisworks', 'submittals', 'modeling', 'construction drawings', 'AutoCAD', 'sustainable design', 'metal fabrication', 'renovation' and 'steel' [23]. Accordingly, specific BIM jobs and BIM skills are often defined by observing BIM trends and practices in the construction industry, industry perceptions, job advertisement, interviews with BIM experts, etc. Therefore, AEC programs need to integrate BIM education within their curricula to ensure adequate education for future civil engineers and prepare them for their future career in real construction sector. Thus, both academia and industry need to focus on BIM education and cooperate in BIM issues to maximize benefits from BIM usage [10].

According to previous study [24] BIM education in the field of construction management at Technical University of Košice, Faculty of Civil Engineering is not fully extended to the Master´s level (2nd level of education). There are some courses with BIM education, but not in the construction management field. Students have good opportunity to get acquainted with BIM but acquired knowledge is more theoretical than a practical one. Likewise, the academic experience which is reached through BIM education at University of Zagreb, Faculty of Civil Engineering is a single course collaboration because BIM is introduced only through one discipline within university [25]. From the above is evident that specific data about learning outcomes and necessary knowledge areas connected with BIM education in

CM field currently does not exist. Additionally, deeper analyses of implemented BIM education and BIM courses is necessary to define the way of their extension [19]. So, the aim of this paper is to compare and discuss educational approaches in BIM education of civil engineers (specifically at the Faculty of Civil Engineering Košice and Faculty of Civil Engineering Zagreb) in order to define guidelines for the further development of BIM education on mentioned faculties.

First, this paper presents methodology of the research and then it gives the results of research conducted at the Faculty of Civil Engineering Košice and the Faculty of Civil Engineering Zagreb. The paper brings discussions by comparing the results with similar education studies (master study, CM program). In the end, the paper gives conclusion and proposes how to improve BIM education practices on both faculties.

2. Methodology

In this study we surveyed the students after they finished their BIM education on their level of study (master study in Construction Management field). They were asked whether they have acquired the required skills in working with BIM tools but also the basic knowledge about the BIM concept. Moreover, we will use student's perception of current BIM training to asses and analyze current educational practices in construction management area in Croatia and Slovakia. All the students who participated in survey (86 students) have been on the first or second year of graduate study, Construction Management study program. 34,89% (53,3% on first year; 46,7% on second year) of them study at the Faculty of Civil Engineering Košice while 65,11% (57,1% on first year; 42,9% on second year) of participants study at the Faculty of Civil Engineering Zagreb.

The survey consisted of 4 types of questions. The first two types were closed type of questions (yes / no and closed select options). In the third type, the respondents had to rate answers using the Likert scale 1-4 (given scale; 1-minimum value of the offered answers; 4-highest value to an answer). The comparative analysis of the two university groups was based on the Relative Importance Index (RII), according to the formula (1):

$$RII = \frac{\sum w}{A \times N} \qquad (1)$$

where w represents the assessment or response of the individual participant of the survey, A, the highest score given by the survey participants while N is the total number of respondents who participated in the study [26]. RII refers to a value in the range from 0 to 1. The higher value of the index RII means that element is more important or has better perception [27, 28]. In fourth type of questions we gave students list of BIM competencies connected with BIM processes, BIM technology and BIM applications and they should rate their level of knowledge (theoretical, practical or both) acquired thought their BIM education. One of the option was that listed BIM competency was not included in their BIM education. When doing list of BIM competencies we used identified specific BIM competency topics by Sacks and Pikas which are necessary to realize through the first or master degree level of CM study [12]. We added 'Cost management' as additional BIM competency in categories BIM processes and BIM technology.

3. Results

According to previous studies [24] at the Faculty of Civil Engineering Košice BIM education has been part of undergraduate and graduate study while at the Faculty of Civil Engineering Zagreb the students had never heard about BIM before entering the graduate level of study [24, 25, 27, 28, 29]. After BIM education at their faculties most students could define BIM (Košice 90%, Zagreb 100%, Table 1). Table 1 shows how application of BIM brought progress in education and increased student's understanding of the construction management (Košice 100%, Zagreb 98,21%, Table 1), and consequently allowed progress in education and understanding of the construction management discipline (Košice 83,33%, Zagreb 98,21%, Table 1). Likewise, respondents from Košice thought that past CAD and Microsoft tools (CAD and Microsoft tools) are sufficient (73,33%, Table 1) for realistic planning and for complex projects which today's construction industry is exposed to, while the respondents from Zagreb thought completely different (8,93%, Table 1). Moreover, most of the students thought that integration of technical specification with costs and time plans (Košice 96,67, Zagreb 96,43%, Table 1), as well as communication between stakeholders who are involved in construction projects, are the areas which are completely missing (Košice 96,67, Zagreb 100%, Figure 1). Further, most respondents wanted to use BIM in their future practice (Košice 80%, Zagreb 100%, Table 1).

Table 1. Comparison of students' answers on specific YES/NO questions

QUESTION	KOŠICE		ZEGREB	
	YES	NO	YES	NO
Can you define Building Information Modeling (BIM)?	90,00%	10,00%	100,00%	0,00%
In your opinion application of software tools that are currently available on the market can improve construction management processes.	100,00%	0,00%	98,21%	1,79%
In your opinion application of BIM technology allows progress in education and understanding of the construction management discipline.	83,33%	16,67%	98,21%	1,79%
In your opinion CAD and Microsoft tools (Word, Excel, Microsoft Project) are sufficient for proper and realistic planning.	73,33%	26,67%	8,93%	91,07%
In your opinion construction industry requires the integration of technical specification with costs and time.	96,67%	3,33%	96,43%	3,57%
In your opinion in the construction industry there is a need for better communication of different professions during the project design and execution.	96,67%	3,33%	100,00%	0,00%
Would you like to use BIM in the near future practice?	80,00%	20,00%	100,00%	0,00%
In your opinion software tools, which are currently promoted as BIM applications, can mutually exchange information, different formats, standards (e.g. Vico and Navisworks or ArchiCAD and Revit).	83,33%	16,67%	76,79%	23,21%

The results also showed that respondents saw construction companies in their country very inefficient with BIM usage 0-25% (Košice 77%, Zagreb 100%, Figure 1, left) but they also think that percentage of BIM usage in the world is pretty higher 50-75% (Košice 54%, Zagreb 68%, Figure 1, right).

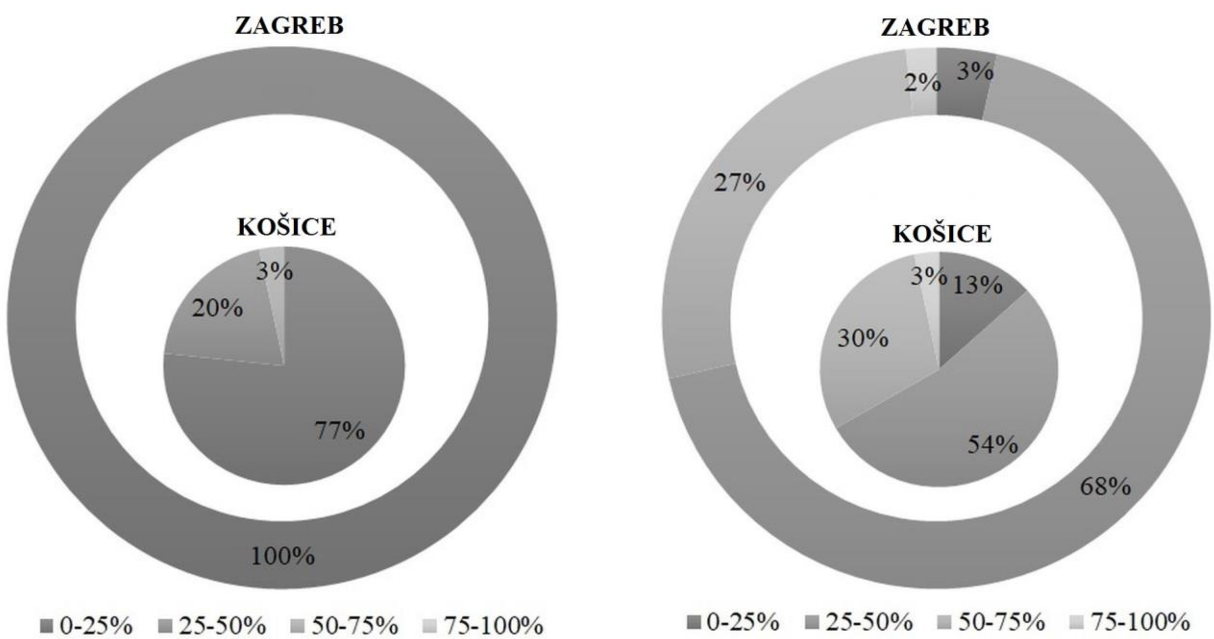

Fig. 1. Comparison of students' answers on question: 'In which percentage do you think that BIM technology is applied in your country (left figure) / in the world (right figure)?'

Additionally, the BIM software which were used in education (Košice 83,33%, Zagreb 76,79%, Table 1) were generally compatible with one to another. At the Faculty of Civil Engineering Košice best rated software were iTWO 4.0 (0,86, Figure 2), BIM Estimate (0,83) and Nemetschek Nevaris (0,83) while at the Faculty of Civil Engineering Zagreb best performance had Nemetschek Allplan (0,89, Figure 2), GALA Construction Software (0,79, Figure 2) and Autodesk Navisworks (0,72, Figure 2). We should highlight here that at the Faculty of Civil Engineering Košice more than 75% of participants have never used Cubit Buildsoft, Exactal COST X, GALA Construction Software, iTWO 4.0. and Synchro PRO while at the Faculty of Civil Engineering Zagreb more than 90% of survey participant have never used software, Cenkros, Cubit Buildsoft, Exactal COST X, INNOVAYA Visual Estimate, iTWO 4.0, Kalkulus, RSV and Synchro PRO.

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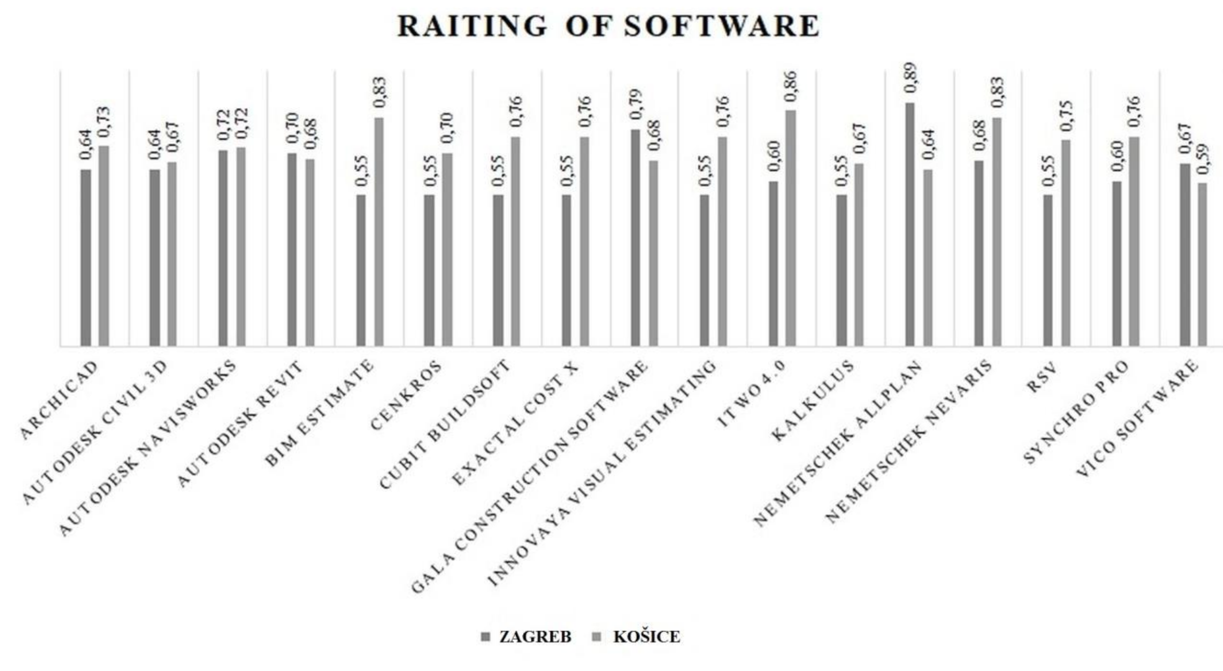

Fig. 2. Comparison of software rating

Besides, results (Table 2) show that students at master's level of study at both universities in general acquired theoretical knowledge connected with BIM processes while only 'Cost Management' is included in theoretical and practical knowledge at the Faculty of Civil Engineering Zagreb (51,79 %, Table 2). Moreover, BIM competencies 'Data security' (46,67%, Table 1) and 'Design coordination' (36,67%, Table 1) were missing in BIM education at the Faculty of Civil Engineering Košice while 'Data security' (48,21 %, Table 1), 'Constructability review and analysis' (41,07%, Table 1) and 'Contractual and legal aspects of BIM implementation' (58,93%, Table 1) were missing in BIM education at the Faculty of Civil Engineering Zagreb. It can be concluded due to higher percentage of respondents who thought that this BIM competencies were not included in BIM education.

Table 2. Students' rate of the competency acquired by learning the following BIM processes throughout their education

BIM PROCESSES	**KOŠICE**				**ZAGREB**			
	T	**P**	**T&P**	**NO**	**T**	**P**	**T&P**	**NO**
Overall construction design management and contracting procedures	**60,00%**	0,00%	20,00%	20,00%	**67,86%**	1,79%	21,43%	8,93%
Facility maintenance and management	**46,67%**	10,00%	10,00%	33,33%	**66,07%**	0,00%	10,71%	23,21%
Advantages and disadvantages of BIM for design and construction processes	**40,00%**	0,00%	33,33%	26,67%	**57,14%**	3,57%	35,71%	3,57%
Model-progression specification and level-of-detail concepts	**46,67%**	6,67%	20,00%	26,67%	**57,14%**	1,79%	3,57%	37,50%
Changes in management procedures	**63,33%**	6,67%	6,67%	23,33%	**53,57%**	0,00%	8,93%	37,50%
Data security	36,67%	3,33%	13,33%	**46,67%**	41,07%	0,00%	10,71%	**48,21%**
Information integrity	**50,00%**	3,33%	13,33%	33,33%	**50,00%**	1,79%	17,86%	30,36%
Design coordination	30,00%	3,33%	30,00%	**36,67%**	**55,36%**	1,79%	19,64%	23,21%
Constructability review and analysis	**50,00%**	0,00%	16,67%	33,33%	33,93%	1,79%	23,21%	**41,07%**
Management of information flows	**46,67%**	3,33%	13,33%	36,67%	**44,64%**	1,79%	10,71%	42,86%
Contractual and legal aspects of BIM implementation	**53,33%**	3,33%	6,67%	36,67%	39,29%	1,79%	0,00%	**58,93%**
BIM standardization (in organizations and projects)	**63,33%**	0,00%	10,00%	26,67%	**67,86%**	1,79%	10,71%	19,64%
Cost management	**46,67%**	3,33%	20,00%	30,00%	37,50%	3,57%	**51,79%**	7,14%

Furthermore, Table 3 shows that students at the Faculty of Civil Engineering Košice only acquired theoretical knowledge about 'Basic BIM operating skills' (53,33%, Table 3) and 'Laser scanning' (40,00%, Table 3) while other competencies connected with BIM technology were not included in BIM education. Students at the Faculty of Civil Engineering Zagreb acquired: only theoretical knowledge connected with ‘Communication tools, media, channels and feedback’ (42,86%, Table 3), ‘Ways to store and share information (e.g., cloud computing, networking, big-room equipment)’ (41,07%, Table 3) and ‘Choosing right BIM technologies/ processes/tools for specific purposes’ (50,00%, Table 3); theoretical and practical knowledge about ‘Basic BIM operating skill (80,36%, Table 3), ‘Modeling with standard catalog elements’ (60,71%, Table 3), ‘Creating and modeling with custom elements’ (50,00%, Table 3) ‘Interoperability (file formats, standards, and structure for data sharing)’ (64,29%, Table 3) and ‘Cost management’ (44,64%, Table 3) while ‘Massing/solid modeling’ (66,07%, Table 3), ‘Central databases/information repositories’ (33, 93%, Table 3) and ‘Laser scanning’ (91,07%, Table 3) were missing in BIM education.

Table 3. Students’ rate of the competency acquired by learning the following BIM technology throughout their education

BIM TECNOLOGY	KOŠICE				ZAGREB			
	T	P	T&P	NO	T	P	T&P	NO
Basic BIM operating skills	**53,33%**	13,33%	13,33%	20,00%	14,29%	1,79%	**80,36%**	3,57%
Modeling with standard catalog elements	20,00%	13,33%	23,33%	**43,33%**	12,50%	3,57%	**60,71%**	23,21%
Creating and modeling with custom elements	30,00%	10,00%	23,33%	**36,67%**	10,71%	5,36%	**50,00%**	33,93%
Massing/solid modeling	36,67%	10,00%	13,33%	**40,00%**	16,07%	3,57%	14,29%	**66,07%**
Central databases/information repositories	36,67%	6,67%	16,67%	**40,00%**	28,57%	5,36%	32,14%	**33,93%**
Interoperability (file formats, standards, and structure for data sharing)	20,00%	10,00%	30,00%	**40,00%**	28,57%	1,79%	**64,29%**	5,36%
Communication tools, media, channels and feedback	16,67%	20,00%	13,33%	**50,00%**	**42,86%**	3,57%	16,07%	37,50%
Ways to store and share information (e.g., cloud computing, networking, big-room equipment)	26,67%	13,33%	16,67%	**43,33%**	**41,07%**	3,57%	25,00%	30,36%
Choosing right BIM technologies/processes/tools for specific purposes	20,00%	10,00%	13,33%	**56,67%**	**50,00%**	7,14%	17,86%	25,00%
Laser scanning	**40,00%**	10,00%	23,33%	26,67%	5,36%	0,00%	3,57%	**91,07%**
Cost management	33,33%	13,33%	16,67%	**36,67%**	33,93%	5,36%	**44,64%**	16,07%

Moreover, results in Table 4 show that students at the Faculty of Civil Engineering Košice acquired theoretical knowledge about ‘Perform structural analysis’ (36,67 %, Table 4) and ‘Rapidly generate and evaluate construction plan alternatives’ (43,33 %, Table 4) while students at the Faculty of Civil Engineering Zagreb acquired theoretical and practical knowledge about ‘Create renderings and representations for aesthetic evaluation’ (55,36%, Table 4), ‘Perform automated quantity takeoff and cost estimation’ (73,21%, Table 4), ‘Perform automated generation of drawings and documents’ (39,29%, Table 4), ‘Perform 4D visualization of construction schedules’ (58,93%, Table 4) and ‘Monitor and visualize process status’ (42,86%, Table 4). Other competencies connected with BIM applications were not included in BIM education at any faculty.

Table 4. Students’ rate of the competency acquired by learning the following BIM applications throughout their education

BIM APPLICATIONS	KOŠICE				ZAGREB			
	T	P	T&P	NO	T	P	T&P	NO
Create renderings and representations for aesthetic evaluation	30,00%	6,67%	16,67%	**46,67%**	5,36%	5,36%	**55,36%**	33,93%
Rapidly generate multiple design alternatives	33,33%	13,33%	16,67%	**36,67%**	23,21%	3,57%	23,21%	**50,00%**
Perform energy analysis	26,67%	6,67%	10,00%	**56,67%**	7,14%	0,00%	1,79%	**91,07%**
Perform structural analysis	**36,67%**	13,33%	13,33%	**36,67%**	7,14%	0,00%	7,14%	**85,71%**
Perform automated quantity takeoff and cost estimation	33,33%	3,33%	16,67%	**46,67%**	12,50%	8,93%	**73,21%**	5,36%
Check code compliance	16,67%	10,00%	6,67%	**66,67%**	5,36%	0,00%	3,57%	**91,07%**
Evaluate conformance with program/client values	23,33%	10,00%	10,00%	**56,67%**	14,29%	1,79%	0,00%	**83,93%**
Detect clashes	26,67%	13,33%	3,33%	**56,67%**	35,71%	5,36%	14,29%	**44,64%**
Perform automated generation of drawings and documents	16,67%	10,00%	30,00%	**43,33%**	19,64%	3,57%	**39,29%**	37,50%
Perform multiuser editing of a single-discipline model; multiuser viewing of merged or separate multidiscipline models	23,33%	16,67%	6,67%	**53,33%**	21,43%	1,79%	10,71%	**66,07%**
Rapidly generate and evaluate construction plan alternatives	**43,33%**	6,67%	10,00%	40,00%	17,86%	3,57%	26,79%	**51,79%**
Perform automated generation of construction tasks	30,00%	3,33%	13,33%	**53,33%**	21,43%	5,36%	26,79%	**46,43%**
Perform discrete event simulation	30,00%	16,67%	3,33%	**50,00%**	14,29%	3,57%	33,93%	**48,21%**
Perform 4D visualization of construction	30,00%	10,00%	10,00%	**50,00%**	19,64%	7,14%	**58,93%**	14,29%

schedules								
Monitor and visualize process status	36,67%	6,67%	10,00%	**46,67%**	19,64%	5,36%	**42,86%**	32,14%
Export data for computer-controlled fabrication	20,00%	6,67%	16,67%	**56,67%**	12,50%	3,57%	35,71%	**48,21%**
Integrate with project partner (supply chain) databases	20,00%	10,00%	6,67%	**63,33%**	23,21%	1,79%	7,14%	**67,86%**

4. Discussion and conclusion

The results show that, by the applied BIM education at the Faculty of Civil Engineering Košice and Zagreb, students have gained basic BIM knowledge and that students are in general satisfied with acquired BIM skills and BIM tools used in their education. Moreover, they are aware that BIM has been used less in Croatia and Slovakia than in other countries in EU.

The literature review showed that constructability, 4D scheduling, model based estimating, model based design, visualization, sustainability, communication, collaboration, clash detection and interoperability represent important knowledge areas for CM BIM education [3, 14, 15, 17]. According to research, only constructability, model based estimating and collaboration have been acquired through BIM education at the Faculty of Civil Engineering Košice but only as a theoretical knowledge. On the contrary, at the Faculty of Civil Engineering Zagreb 4D scheduling, model based estimating, model based design, visualization and interoperability have been achieved as theoretical and practical knowledge; communication and collaboration only as a theoretical knowledge while constructability, sustainability and clash detection have not been included within BIM education but represent important knowledge areas. Thus, students at the Faculty of Civil Engineering Košice and Zagreb after BIM education have had basic BIM skills required for BIM mangers/engineers and BIM project managers identified by Wang and Laite [2]. BIM education at the Faculty of Civil Engineering Košice should be upgraded with practical BIM training to teach students how to use adequate BIM tools in CM field.

Likewise, thought this research we evaluated realization of 39 specific BIM competency topics through BIM education of master level of study at the Faculty of Civil Engineering Košice and Zagreb identified by Sacks and Pikas [12, 13]. According to results BIM knowledge acquired by learning BIM processes at both faculties is generally theoretical while BIM knowledge acquired by learning BIM technology at the Faculty of Civil Engineering Zagreb is theoretical or theoretical and practical. Finally, knowledge connected with BIM technology at the Faculty of Civil Engineering Košice and knowledge connected with BIM applications at both faculties has mainly not yet included in the CM educational processes.

Besides, academic experience which has been reached through the education at the Faculty of Civil Engineering Košice and Zagreb, has been single course collaboration [24, 25] because BIM has been introduced only through one discipline within the each of university separately. Therefore, education has to be extended through two or more departments and disciplines. This extension will provide students wider knowledge about interoperability, integration, communication, collaboration and clash detection which are definitely missing at both faculties.

With this study we confirm importance of including BIM training in educational process of higher student's education while BIM education should be part of undergraduate, graduate and postgraduate study. Currently BIM is included in educational processes at many faculties but BIM training is often not adequate for real complex projects. Reasons for this can be found in inadequate and not educated staff, inadequate resources and support to make the curriculum change and that there is no space left within curricula. Furthermore, our research shows that BIM education at the Faculty of Civil Engineering Košice and Zagreb has not been directed only to software training but theoretical knowledge about BIM concept is important part of BIM training. Moreover, when develop BIM framework, BIM courses, curricula and content, student's perception and feedback should play important role [6] so our research is good start point for further development of BIM education in Croatia and Slovakia. Finally, to spread BIM education and to reach missing BIM learning outcomes, connecting BIM education with other departments on the same faculty and other disciplines as well as connecting it with real companies and projects is necessary. Once it is done, creating and adapting curricula will not be a problem while academia, students and participants from real sector will utilise all values and benefits of BIM application.

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