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The integration of BIM in education: a literature review and comparative context

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ABSTRACT: The objective of this article is to provide insights into the integration of building integration modelling (BIM) for the educational system in Kosovo. The research method consists of empirical and comparative contextual observation, with the objective of surveying how the educational system could integrate BIM in applying principles in building design and construction over the life-cycle process. The article reviews the literature in the light of research questions: What is the role of BIM in education for architecture and construction in the context of Kosovo? How could the response to BIM affect the education systems of Kosovo's universities? Establishing the BIM skilled candidates, needed by industry now, as BIM adoption accelerates, must meet the government mandate; thus, make closer links between industry and academic institutions. Expected learning outcomes on different levels, outlined in this article, will address BIM as a minimum tool in the near future, starting from educational institutions, designers, builders or clients, focusing on how shall BIM be introduced and required by Kosovo government laws in the near future.

Keywords: BIM, education, architecture, construction, industry

INTRODUCTION

Among the range of definitions, building information modelling (BIM) is understanding a building through the use of a digital model, an asset in digital form that enables those who interact with the building to optimise their actions, resulting in a greater whole-life value for the asset [1]. Recent advances in IT have enabled advanced knowledge management, which in turn facilitates sustainability and improves asset performance and management in the architectural, engineering and construction (AEC) industry. The BIM products use three-dimensional, real-time and dynamic building modelling software to increase productivity in building design and construction phases. In this direction, learning methods in the higher education of architecture and construction are changing in contemporary worldwide education systems. Thus, the knowledge or skill acquired by instruction or study of architecture and construction today also requires the activity or process of studying, practicing, being taught about the achievements in information technology (IT), such as: building information modelling (BIM), unmanned aerial vehicles (UAV) systems, laser scanners, or/and other digital tools. Today, it is crucial for the universities to introduce BIM as an education-promising tool, since in general it helps to create opportunities for advanced collaboration and project coordination in the client - designer - builder triangle, and develop building design documentation and construction processes.

The concept of BIM emerged theoretically and was developed at Georgia Institute of Technology in the late 1970s and grew rapidly after that. The growth happened, because of the increased attention being paid to construction teams and firms that found merit in using BIM in order to integrate the process of construction projects and managing them. The term BIM was first used in 2002 to describe virtual design, construction and facilities management [2]. In this direction, the article highlights advantages of BIM maturity, particularly the increased utility and speeds that have enhanced all construction phases in correlation to the education system [3].

RESEARCH QUESTION

Theoretically and practically, BIM-skilled users in Kosovo are between levels 0-1 compared with the global context so far. A need for sustainability, and development in general, requires BIM to have an emphasised role in the educational system, into the syllabus, and further to industry and facility maintenance. The aim of this research is to identify the role of BIM in education towards sustainability and performance of buildings, including recommendations for process implementation in the building industry. In this context, the research questions to be addressed are: How can the BIM role in interrelation with sustainability, and in asset performance over the life cycle, be identified? How can recommendations for BIM implementation be identified? Where to look for the university role in BIM education/training? Is it better to focus on the medium and long term in training?

The benefits of this process revealed a number of challenges faced by the construction sector, including: the need to improve the strategic vision with regard to sustainability (from within the industry, local and national government); resistance to the implementation of new, more efficient technologies; and inefficient logistics and communication methods inhibiting the adoption of new technologies to improve efficiencies [4]. Therefore, it is important to start recruiting skilled and professional BIM candidates in order to have a sustainable impact on building/construction industry.

Therefore, a detailed literature review and comparative survey was performed in order to present the status of BIM education in Kosovo universities and to formulate a framework that will provide guidelines for implementing BIM, in particular to start developing a BIM curriculum. As a result, universities will be able to produce graduates who are equipped with the necessary knowledge and skills of the modern tools, such as BIM before they enter their professional careers [5]. However, when these challenges can be overcome, BIM as a new information technology promises a new level of collaborative engineering knowledge management, designed to facilitate sustainability and asset performance issues in the life cycle of AEC industry of Kosovo.

BIM BACKGROUND INFORMATION AND GENERAL RELATIONS

The appearance of computer-aided design and manufacturing (CAD/CAM) increased the speed of documentation work and prefabrication processes in all fields of engineering and also in the construction industry [6]. The integrated concurrent engineering (ICE) process even reduced the time span between the project idea and execution further, requiring an even tighter integration among different design disciplines [7]. The next trend in the industry was the integrated solution offered for construction companies. This approach is also known as 5D BIM (3D+time+cost). The latest and growing trend is supplementing the BIM models with facility management and life-cycle management information, which will help the work of building operators (6D-7D BIM). Thus, numerous sequential activities can be coordinated and performed at the same time, using virtual reality models. These integrated design models containing multidisciplinary data and the most up-to-date design process, collocated multidisciplinary teams work with the same data stored on model servers. The BIM maturity model, created by Bew and Richards [8], consists of four levels of maturity as illustrated in Figure 1. The index can measure BIM maturity in individual projects, as opposed to measuring maturity on an organisational level. For instance, the UK government has decided that all its construction projects should use BIM level 2 by 2016. Below is a description of the different levels in the model.

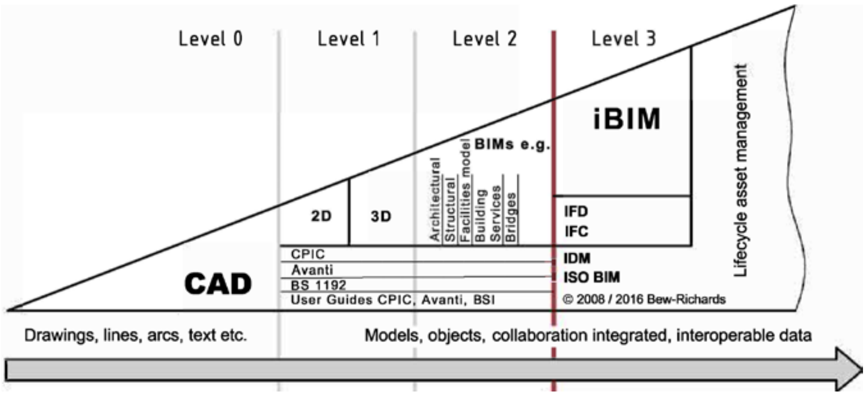

Figure 1: BIM maturity model [8].

Level 0 of the maturity model should be seen as the starting point for an organisation about to adopt BIM. This level is defined as unmanaged 2D drawings, either paper-based or digital. Level 1 is the first step for an organisation trying to adopt a BIM strategy. This level means more managed CAD, usually in both 2D and 3D. 3D models are typically used for concept work, while 2D drawings are used for the approval process, as well as for the production. However, the models are not shared between project team members. Each discipline maintains and manages its own data. In Level 2, the models have become managed 3D environments and data tied to BIM objects are included in the model. These data make it possible to perform scheduling and estimation with the model. The different disciplines create individual models, which are then combined into one, but without any loss of data [8].

This means that the different disciplines have started to collaborate more and more through more structured information exchange. However, as mentioned above, the different disciplines do not collaboratively create a single shared model. They still create individual models. A common file format should be used to share design information between the different actors. The IFC is one example of a neutral file format that is compatible with different software [2]. This allows the design models to be combined with other models in order to perform a range of analyses. Level 3 integrates data into one single project model, which is collaborative and located on-line on a shared server. Cost analysis, construction sequencing and project life-cycle information are integrated into the model. This level presents full collaboration between the different parties in a project. The single share project model can be accessed and modified at all times by the parties involved. This means no more inconsistent models.

THE BIM ROLE AND SUSTAINABILITY

BIM is an appropriate tool that helps building owners and operators throughout a structure's life cycle by enabling sustainability, providing a visual context to performance-related data, environmental impact assessment and access to other projects that envisioned increase in energy efficiency. In this regard, the AEC industry is often perceived as being slow in adopting technology and it was claimed that it had old business models and processes for decades. But lately, the design and construction industry is moving towards BIM that provides all of the strengths of traditional 3D CAD with an added layer of data allowing new and powerful applications to be widely used. Both, CAD and BIM are forms of computer-aided building modulation that architects, engineers and contractors use to create and view two- and three-dimensional models.

The AEC industry also uses BIM, a newer computerised modelling system that can create up to six-dimensional models. Bryde et al also argued that an intensive cost-benefit analysis of BIM is required in order to rationalise initial investment by organisations into the technologies and procedural changes [9]. *BIM provides an information-rich model, which can be used throughout the life cycle of a facility, from design through to operation and even after decommissioning. But, like with many things, what comes out of BIM depends on what has been put in, and organisations that invest the resources in the model will see greater long-term gains* [10]. These gains are increasingly driving the design and facility management industries towards BIM, with adoption and innovation within BIM increasing continually [10].

Meanwhile, there is a great diversity in ideas about definitions on the quality of life. Some perceive it as the living environment, the house and the air that people breathe, while others describe it as safety and security, health, wealth (employment), transport infrastructures, adequate building for housing, schooling and recreation [11]. In addition, increased costs of energy, ongoing challenges modelled by the economy and concerns about sustainability, market demands, occupancy and eventual regulation of carbon output combine to make building owners, operators and managers increasingly aware of how their properties perform and compare with others [12].

BIM, LIFE-CYCLE ASSESSMENT AND GLOBAL CONTEXT

Understanding the impact of building materials involves life-cycle assessment (LCA), an in-depth form of analysis performed on whole buildings, manufactured building products and materials and material assemblies [13]. While LCAs provide a complete picture of the environmental impacts associated with a building, the practice of LCA is relatively new and confounding for most building professionals. Until recently, LCAs were typically conducted after construction, rather than during the design and planning process, when the data and BIM could actually influence design decisions.

In principle, architects and other building professionals should be able to conduct LCAs using building information models that are a part of standard architectural practice. In reality, building models do not contain all the ingredients that go into a building. A BIM model might recognise a steel assembly, for example, but it would not take into account that most steel assemblies use a significant amount of concrete as well [14]. In addition to quantifying emissions to land, air and water, a building or material's embodied environmental impacts can also be factored.

Essentially, the BIM syllabuses should focus on the main benefits of using BIM for life-cycle assessment (LCA) underlined, as:

- Reduce downtime - automated monitoring and predictive alerts help one to avoid major defects, prevent long downtimes and address potential performance issues before they escalate. Workflows and case management capabilities speed problem resolution.
- Optimise maintenance cycles - move toward a predictive maintenance model, using timely alerts to prompt maintenance teams to address issues during scheduled outages in a planned, cost-effective way. This enables asset repair or replacement to occur at the optimal time.
- Improve root-cause analysis - quickly and accurately identify root causes using advanced analytics to detect hidden patterns in the data. Standard and *ad hoc* reporting capabilities, along with comprehensive case management workflows, enable one to trouble-shoot and correct performance issues faster and more effectively.
- Enhance data visibility - visually explore integrated data from MES, ERP, CMMS and other systems, and make the data accessible to a wide range of users. Enhanced data visibility makes it easy for analysts to monitor and model asset performance.

The paradigm shift from static notions of building performance to the regenerative contribution of built environment can improve the social, ecological and economic health of the place in which the building functions [15]. To achieve this in Kosovo, common understanding amongst diverse stakeholders is required; a move from an isolated and static understanding of building performance in terms of design dialogue to an expansive and dynamic dialogue that encourages an understanding of the implications of the building life cycle on occupant lives and business success will engage and maintain stakeholder commitment [16].

In Kosovo as in the EU, the next few years of the building and construction industry will be affected dramatically by BIM. BIM merges information about planning, workflows and the operational management of buildings in a common database, the 3D-BIM model, which can be accessed by all partners involved in the building and operating process.

During this stage, the Kosovo government is facing several constraints, including fragmented and not harmonised jurisdictions; lack of political continuity - consensus; poor cooperation between local and central level institutions; poor multi-departmental cooperation; lack of consultancy bodies for architecture (taste) and planning; cultural and ideological dissonance; and a weak system of local government (non-existent law in Pristina, slowly going processes of national codes and licensing of architects and engineers), the need for exact cost assessments, precise drawings, components, descriptors and parameters will be more and more important [17].

To identify the level of BIM implementation in the construction industry and educational institutions, the authors have carried out a survey of universities by investigating syllabuses on the Web pages. Surveys and interviews with several academic staff of universities and managers of construction companies have identified the low level of BIM implementation and emphasised the necessity of having BIM lectures involved in syllabuses for architecture and construction students and the AEC industry. Experience in developed countries has shown that BIM is the best process solution to manage developments quicker, in agreed timescales and for lower prices [18]. The merger of geometrical, material specific, components, descriptors and parameters is one of the key features of BIM and the main variation towards 3D-CAD, running in the AEC industry of Kosovo. So, the user adds the technical specifications of building components information about costs and the interaction between related prototypes and successors. Additional information can be set up either for maintenance expenditures and requirements or recycling solutions at the end of the life cycle of the project.

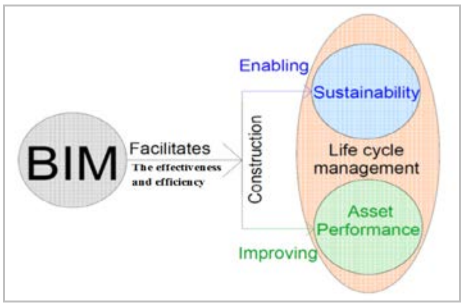

Figure 2: BIM's role in enabling sustainability and asset performance of facilities over the life cycle [18].

With the AEC process, Kosovo can achieve a better prediction of the building process on site and *ad hoc* changes on site will often be avoided. It must be taken in account that BIM requires a higher input in the design process, but the higher productivity on site and lower time and cost consumption in the building process justify this effort. The optimisation in collaboration of all partners involved in the complete value chain of a building is the key success point of BIM. Therefore, it is necessary that all parties must have a common understanding about using BIM from an early stage of design to achieve the greatest benefit by virtual design in quantities, qualities, times and costs [19].

In this direction, it has to be noted that BIM is not a tool to be used just for the major projects. Even in small projects, the efficiency in view to design, building and maintenance processes can be improved. Sometimes BIM is also a suitable tool for single family houses since intended house owners get visible and structured information about their home and the building materials used. But, one should never forget that developments are made by people and for this skilled project teams are needed, who understand the requirement for efficient construction in time, cost and quality frames. In this matter, BIM is the common tool, as shown in Figure 2, to be a standard in the future, taught in educational systems towards stimulating the AEC industry in Kosovo.

ADDRESSING THE CHALLENGES OF BIM IN EDUCATION

The challenges as set out in the previous section need to be addressed when BIM is to be implemented in the Kosovo educational system and syllabuses. Addressing these points will increase its strength and output. In this section some suggestions to mitigate the disadvantages are demonstrated and discussed at the research done by Kivits and Furneaux:

- *A single detailed model - even though BIM is a single detailed model, this should not limit the opportunities for experimenting with different versions in the design phase. In this phase, if desired, two or more initial models could be initiated, giving the designer room to experiment with alternative design schemes. This is assumed to take up a lot of storage space, but as the design progresses, in time only one design will remain. Together with the latest advances in IT technology, which allow for increasing storage capacity, this disadvantage could become less challenging* [20].
- *Interoperability - as it is vital for the success of BIM that all participating parties of the project use the same programs, the same versions of programs, and IFC standards, this will have to be accomplished before starting the project. In the initiation stage, all participants will have to agree on switching to the new standard if they are not using it yet. Another option would be only entering arrangements with partners that comply with the requirements beforehand. In this way, interoperability challenges are addressed, and incompatibilities leading to delays can be avoided* [20].
- *Added work for the designer - certain incentives for the designers and architects of the model will have to be integrated in the contracting process, as the initial creators of the model, the designers and architects have a big*

influence on the future development of the model. The initial design stage, therefore, carries extra responsibilities, liabilities and work. Straightforward monetary rewards can be offered to the designer to compensate them for the work, or certain arrangements like royalties for artists could be incorporated when the underlying data of the model are used again. However, these are just suggestions and, as such, have not yet been researched, whether they are possible or legally achievable. It is however clear that the job description of the architect changes in BIM processes. Some of the issues, which need to be resolved for this to happen, particularly IP, are to be discussed in more detail [20].

- *The size and complexity of BIM - as addressed earlier, developments in the Internet and computer technology have greatly enabled the options available for larger and more complex technological projects. In general, just the storage of the model should not create much of a problem, as storage space becomes increasingly cheaper. Greater difficulties will arise in creating real-time access and the sharing of the database; ubiquitous high-speed broadband Internet is essential, together with ways of ensuring that the data are secure, stable and accessible. The key here is generating and/or accessing the right data for the right purpose, rather than accessing all the data* [20].

The AEC industry in Kosovo is transitioning from a *file-based environment* toward a *data-based environment*. Consequently, the information stored in the BIM models can be shared in various file formats with external project team members. These formats include IFC (industry foundation classes), DXF-DWG (AutoCAD drawing), PDF (portable document format), XML (extensible mark-up language), and other native CAD file formats. IFC, in particular, is a standard universal framework that enables information sharing and interoperability throughout all phases of the whole building life cycle.

CONCLUSIONS

BIM's education demand in AEC's programmes is almost pronounced globally and should not be ignored in Kosovo. An innovative educational programme presented within the universities, which should specify a proposed change of teaching for AEC engineers, should focus on consideration and fulfilment of activities - requirements, such as:

1) Teamwork of specialists from different fields with a clear division of duties and competencies – currently, there is a shortage of employees who are able to work with a BIM inclusive technology in architecture, civil engineering, and construction.
2) BIM design support software, used by architects, builders, installers, etc. in line with each other - in this respect BIM should be seen not only as a piece of software but as an integrated process of using building ideas on the modelling principle of information, basically, a data packet that may include all relevant information throughout the life cycle of the building, from design, construction, building management, renovations to demolition.
3) Organisation of database usage in a way to eliminate collisions between different fields - do not underestimate the integrated cooperation of the faculty representatives within a university to model the BIM program implementation with the data from architectural, engineering, engineering, and systems of buildings, in the context of Kosovo.

The above-mentioned inter-operable activities should be considered to be fundamental principles in the process of drafting and implementing the curriculum at the university. Moreover, there should also be a school assignment - thought design and action using BIM technology and software, at least for three semesters.

RECOMMENDATIONS

In developed countries, BIM tools and processes will become mainstream in the AEC market approaches. The demand for skilled BIM professionals in the Kosovo context will increase steadily and, then, dramatically. It is recommended that regional universities properly adapt their curricula to turn their graduates into professionals able to perform as those required specialists.

As a means of strengthening the linkage between the traditional and modern methods of AEC education in the regional universities, there is the need to encourage research into BIM by BIM tutors, improving upon the current teaching curriculum for BIM tools, firstly in the department of architecture. The syllabus should be designed to create conducive methods for the teaching and learning of BIM. The adoption of CAD, Revit Architecture as the main tool for CAD courses today, could be easily encouraged and increased in BIM skills courses for students and/or there should be established an elective BIM course with a number of credit hours; thus, to increase further skills for CAD/BIM at once.

BIM should be taught as an integral part of the urban-architectural-construction design studios from the 2nd year to the 5th year. Finally, students should be examined at the end of the BIM-conducted project rather than having their marks accrued from quizzes into the overall marks of their examinations.

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BIOGRAPHIES

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