COMMON BIM USES: EXPERIENCE-BASED RESEARCH

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ABSTRACT

This paper intends to reveal the current status of Building Information Modelling (BIM) usage and employment in the local Architecture, Engineering, and Construction (AEC) market. Despite the huge benefits of adopting BIM methods to accomplish different AEC objectives, there is uncertainty among AEC professionals regarding BIM uses and applications. The research is based on deep interviews with local BIM experts, it collects detailed information regarding BIM uses in the local Hungarian AEC sector, especially the South Transdanubia region. The paper systematically reviews the literature about BIM uses, associated definitions, implementation methodologies, and related project stages. Thereafter, it identifies the principal BIM uses, components, and categories, by which the drawn data will be classified. The research analyses the gathered information derived from the interviews, presents the most prevalent BIM uses and their frequency factors based on employees' professional experience, identifies the associated classification for each common BIM use, and investigates the connection between the potential BIM uses and the associated AEC disciplines. Furthermore, it reveals opportunities concerning needed BIM uses and their related project phases according to the domestic market's requirements, needs, and trends.

KEYWORDS _ *BIM, Common BIM Uses, AEC Firms & Industry, Deep Interview, Hungary*

INTRODUCTION

Definition of BIM implementation and uses:

BIM stands for constructing digital projects for various AEC and management purposes (Hardin & McCool, n.d.; *The Contractors' Guide to BIM*, n.d.; Wang, 2012). BIM awareness varies remarkably among professionals in the AEC industry, architects are generally more active regarding knowledge, concerns, and views about BIM applications (Gu & London, 2010)a very important part of the research also concerns the application of the technologies and their adoption by the practices. This paper firstly presents an analysis of the current state of BIM in the Architecture, Engineering and Construction (AEC. BIM implementation has two main stages: implementation and post-implementation phases, in the first, the absence of direct and fast benefits is expected, meanwhile, benefits start to appear and expand in the second phase (Tomek & Matějka, 2014). The AEC industry has a multidisciplinary nature, common ground among different stakeholders is essential with multidisciplinary collaboration, and here comes the potential of BIM-based workflows (Pezeshki & Ivari, 2018).

BIM adoption has obstacles, like lack of expertise, immediate benefits, communication, client demand, change resistance, costs, new operations, and legal issues (Eadie et al., 2013). On the other hand, applying BIM methods assures a high overall return on business (Giel & Issa, 2013)engineering, and construction (AEC. BIM adoption is provided by a BIM Execution Plan (BEP), as a process to be followed to assure successful BIM application, by defining valuable BIM uses per project's phases, creating process maps to define the BIM execution operation, identifying the deliverables and the information exchange, and developing BIM adoption infrastructure (required technology, support, communication procedures, quality assurance, and contracts) (Kreider & Messner, 2013). Hence, it is an essential and initial step to understand and identify needed BIM uses at the early stages of any project.

BIM use is achieving one or more specific objectives by applying BIM at any stage of the project. BIM uses directly affect the data needs, and each stakeholder has different data needs (Aksomitas, n.d.; Kreider & Messner, 2013). The taxonomy of model uses defines the usage primarily by the purpose it fulfills within the phase of the project, bearing in mind that some BIM uses can be applied in one or more project phases (Stefani, 2020).

Stakeholders should identify which BIM uses and deliverables should be accomplished in the project. Objectives and uses should be defined at the beginning of the project since it is hard to adopt extra functions to the models later on. Noteworthy, BIM uses to develop and expand with time, and so do the processes and software tools, so being up to date is a must (*CIC Building Information Modelling Standards*, 2015). Taking on a successful BIM process starts with the end in mind, team members must understand the future usage of the data that is developed, due to its effect on the model's development method (Messner et al., 2021).

COMMON BIM USES, RELATED PROJECT PHASES, AND RESEARCH OBJECTIVES:

Regardless of the different approaches for BIM description, it is substantial to identify BIM uses as an initial and essential step toward successful BIM implementation (Matějka & Tomek, 2017), BIM uses can be classified based on several criteria (e.g. the project phase at which the certain BIM use will be implemented to achieve the desired goal), table 1 reviews the literature regarding BIM uses and their related project phases.

Table 1: A literature review of BIM uses

Reference	Project Phase	BIM Uses
(Azhar et al., 2012)	Project programming, design, and pre/during construction stages.	(Space analysis, land regulations, and site complexity analysis), (schematic, detailed, and construction design), and (constructability analysis, site coordination, estimating, request for information (RFI), extracting data, progress monitoring, and coordination meetings), respectively.
(Ham et al., 2008)	Design and pre-design stages.	Decision-making, coordinating projects, architectural planning, and advanced analysis studies.
(Gu & London, 2010)	All project phases.	Marketing, display for clients, sub-models of discipline design, interdisciplinary design collaboration, multidisciplinary design collaboration, design review, design analysis, subcontractor tender, construction information management, facility management operations, and facility management maintenance
(Hartmann et al., 2012), (Hardin & McCool, n.d.)	Construction phase.	Construction management, risk management, quantity take-offs, and cost estimations.
(Tomek & Matějka, 2014)	Planning, design, construction, and operation stages.	budget analysis, quantities, site analysis, time schedules, certification, project/site design, engineering analysis, documentation, coordination, current-condition modeling, operation planning/management, fabrication, facility management, crisis management, demolition plan, reconstruction/renovation plan.
(Eadie et al., 2013)	Design stage.	Feasibility, documentation, and design coordination.
(Azhar & Brown, 2009)	Early/late design and early construction stages.	Building performance analysis, assuring sustainability, and optimal performance.
(Cao et al., 2015)	Design and construction stages.	Clash detecting, 3D presentation, design of construction systems, design coordination, and design options analysis.
(Giel & Issa, 2013)	Design and early construction stages.	RFIs, schedule control, order changes, and documentation.
(Aksomitas, n.d.), (Messner et al., 2021)	Planning, design, construction, and operation.	Existing condition modeling, cost estimation, phase planning/scheduling, site analysis, and programming, 3D coordination, clash detection, design review, produce drawings, design authoring, engineering/sustainability analysis, quantity takeoffs, safety planning, construction sequencing, prefabrication, site scheduling, maintenance scheduling, asset management, building system analysis, disaster planning, record modeling, and space planning/coordination.

It is essential to understand that BIM does not change the targets that stakeholders are looking for, it just changes the ways these targets are approached, and these ways are identified in the BEP by detailed BIM usage process maps (Kreider & Messner, 2013). This introduction shows the potential of understanding BIM uses in the initial stages, and because this research is part of a larger research scheme, to study the effect of BIM implementation on the construction productivity of AEC firms in the region. Hence, it is important to investigate the current common BIM uses that are adopted in the construction projects by various AEC firms with clearly published BIM missions, in their daily professional work. The expected results will provide a clear view of common BIM uses and their related project phases, an overview of the discipline of the BIM-supported companies, and an insight into the potential revealed and unrevealed BIM uses and their related disciplines within the local AEC industry.

MATERIALS AND METHODOLOGIES

Primary components and purposes of BIM use:

BIM uses have two main components: objectives and characteristics, based on the purpose component, the usages are classified into primary purposes and secondary purposes. On the other hand, based on the characteristic component, usages are sorted by element, phase, discipline, and level of development (Kreider & Messner, 2013). The paper focuses on BIM uses at the local Hungarian AEC firms' level, mainly firms located in the South Transdanubia region, and adopting BIM workflows. Besides focusing on the potential BIM uses that have high-frequency ratios, and their associated project phases and disciplines, the work will introduce unrevealed BIM uses and related project phases based on the local market's trends. Figure 1 presents the BIM use classification map, in which the scopes that are included in this study will be highlighted.

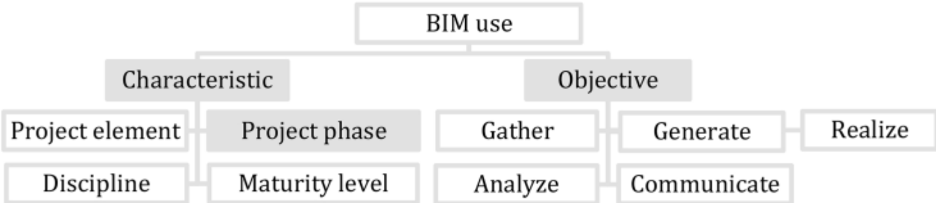

Figure 1: Included BIM Uses Scopes.

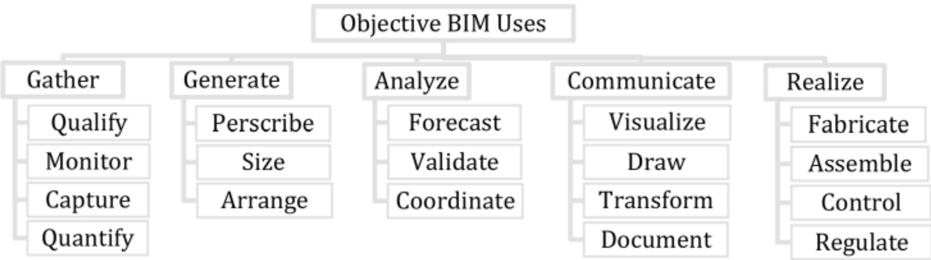

Figure 2: Objective BIM Uses and their Purposes.

BIM uses characteristics assist professionals in further understanding BIM implementation based on the project attributes, so that each particular BIM use can be associated with a specific approach. On the other hand, objective BIM uses can be classified into primary and secondary purposes, see Figure 2. The paper will combine the illustrated criteria for BIM uses components, with the obtained qualitative data from BIM experts, the data will be arranged and associated with the introduced classification to identify the state of the art of BIM usage at local BIM workflow-based companies in the studied region. Moreover, it will reveal the cover from hidden BIM uses and purposes that are still not fully implemented in the local market, this revealed hidden gems will have potential in the industry in the upcoming years.

DEEP INTERVIEWS WITH BIM EXPERTS

The primary advantage of the in-depth interview is the detailed data that can be obtained compared to other qualitative research methods. On the other hand, being prone to bias, time-consuming, highly skilled interviewer, and not generalizable, are among the pitfalls of deep interviewing (Boyce & Neale, 2006). This investigation technique to obtain qualitative data for BIM-related studies has been used in several research studies (Altassan et al., 2023; Hochscheid & Halin, 2018)which makes project data inaccessible and underutilized. Building information modeling (BIM.

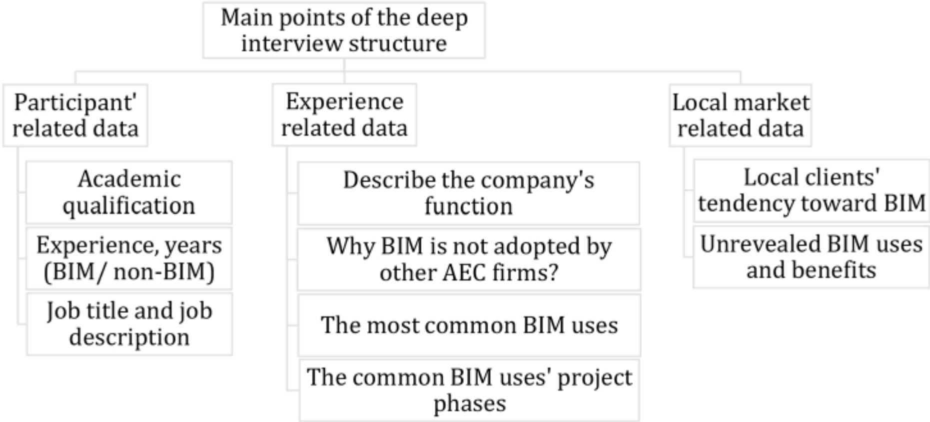

Figure 3: In-depth interview structure.

The implemented methodology is deep interview-based as a qualitative research technique. By conducting intensive interviews with BIM professionals to reveal answers related to BIM uses in the local AEC market, the study developed an in-depth interview protocol to ensure interview consistency (see Figure 3). The interview template includes several techniques to ensure high-quality data, like open-ended questions, factual precede opinion questions, and implementing probes as much as needed. The participants are active employees in BIM-adopted AEC companies, based in the studied region, the sample is diverse regarding years of experience to represent a complete picture. A total of 8 deep interviews were conducted during the 2nd and 3rd quarters of 2023, with around 50-60 minutes duration per each interview.

The interview is divided into three main sections: warm-up questions (participants-related data), core questions (based on experience), and finishing questions (local BIM market orientation). In the first section, participants are asked to answer questions about their academic qualifications, years of experience with job titles, and job descriptions. The second part focuses on the common BIM uses and related project phases based on participants' experiences and descriptions of the firm's main activity. In the last group of questions, the participants are asked to give their opinion about the tendency of the local market toward BIM, and possible opportunities associated with BIM use.

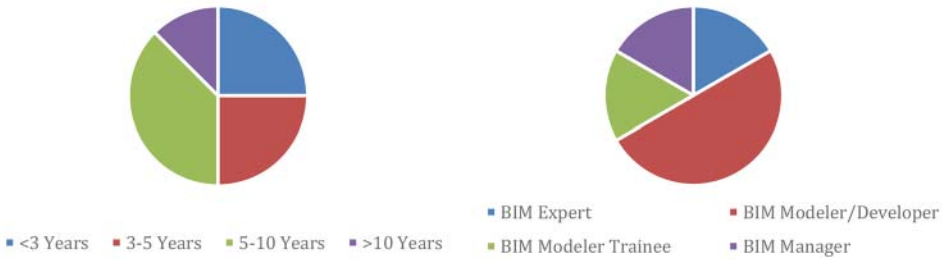

Figure 4: Participants' BIM-related years of experience and job titles.

The participants' BIM-related years of experience vary to represent different categories of employees: less than 3, 3-5, 5-10, and more than 10 years of experience, accounting for 25%, 25%, 38%, and 13% from the sample of participants, respectively. The majority of professionals who work in the BIM field have architectural engineering backgrounds, based on the interviewed sample, 63%, 25%, and 13%, have architectural, structural, and MEP engineering backgrounds.

RESULTS AND DISCUSSION

Based on the facility phase characteristic of employed BIM uses, the design stage is the most frequent phase of built assets at which a large variety of BIM uses are adopted, followed by the construction stage with a slightly lower adoption rate, then with significantly less rates for the operation and planning stages, accounting for 40%, 35%, 15%, and 10%, of the total BIM uses employment, respectively. Interestingly, and in connection with the high adoption of BIM uses during the design stage of projects, it is very rare to identify a design office that adopts BIM processes for accomplishing the assigned appointments and tasks. Only Participant 07 (P07) described his/her company as a structural design company that occasionally uses the help of BIM processes (early stages of implementation). The rest of participants described their companies as technical support, consultancy, and digitalization services firms for AEC projects/tasks. This raises the potential for design offices (architectural and structural) to take advantage of adopting BIM processes and widen their clients' segments, missions, experiences, and revenues, based on the measured high demand from clients to implement BIM during the design and construction stage (mainly late design and early construction stages).

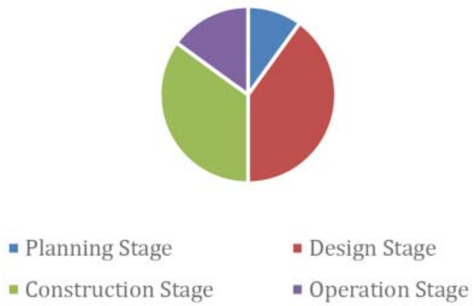

Figure 5: The most common project phases in which BIM uses are employed.

On the other hand, the most common BIM uses based on practitioners' experiences are design related (e.g. audit processes, clash detection, checking information content, comparing different drawings, design review, finding design mistakes/problems, documentation, and 3D coordination) and construction related BIM uses (schedules, quantities, cost estimation, and materials take-offs).

Table 2: Common BIM Uses and their frequency ratios, related project phases, and classification

	Most Common BIM Uses	Frequency Ratio	Associated Project Phase	Associated Classification
01	Design support (audit processes, clash detection, checking information content, comparing different drawings, design review, reporting, documentation, and 3D coordination)	1	Design Phase.	Analyze (validate, forecast, and coordinate), and Communicate (visualize, draw, transform, and document)
02	Construction support (schedules, quantities, cost estimation, and materials take-offs)	0.88	Construction phase.	Gather (qualify, monitor, quantify)

03	Building Analysis	0.13	Design phase.	Analyze (validate, forecast, coordinate)
04	Facility management	0.13	Operation phase.	Realize (control)
05	Modeling existing conditions	0.38	Planning, design, and operation phases.	Gather (capture)
06	Classification of building elements and associating data with them	0.25	Planning, design, construction, and operation phases.	Generate (prescribe, size, arrange)

Major highly frequent BIM uses (e.g., design support) are concurrent among all participants, regardless of the years of experience or job title. Meanwhile, other special BIM uses (e.g., facility management support) are unique for participants who seem to have a sharper overview of the market, mainly coming from management backgrounds and diverse task environment. It is observed that the held position of the participant has a significant effect on the overall insight of the industry compared to the years of experience (e.g., a BIM manager with 10 years of experience would have a wider vision regarding the AEC industry generally and the BIM sector particularly compared to a 20 years experienced BIM coordinator).

Based on the observations of local BIM professionals in the Hungarian AEC market, there is a growing demand from clients to employ BIM processes in various stages of AEC projects, combined with official tendency toward digitalizing the sector, will result in significant expand in the BIM sector, more and more professionals will join BIM trainings and education courses to enrol in the sector. On the other hand, some professionals suggest that many firms are still lagging, they need more effort and assist to induct among BIM leading companies. In addition, participants shared their professional vision in connection with missing, unrevealed, or needed BIM aspects, based on the current data, available services, nature of assignments, barriers, and obstacles; these insights include combining BIM with facility management, algorithmic/parametric design, on-site construction support, and VR/AR.

CONCLUSIONS

The work presents the most common BIM uses and related project phases in Southern Hungary, and is based on local BIM professionals' experiences. The most dominant BIM uses in the market are primary objective BIM uses: analyzing, communicating, and gathering, mostly applied in the design and construction stages. Design support (audit processes, clash detection, checking data content, comparing drawings, documentation, and 3D coordination), and construction support (scheduling, quantities, cost estimations, and material take-offs) are the most frequent uses, indicating the potential of BIM processes for both designers and constructors alike. The results show an opportunity for AEC firms that carry out work during the design (e.g., architectural and structural design offices) and construction (e.g., general contractors) stages of projects to adopt BIM-based processes due to the high ratios of BIM implementation demand at the design and construction stages of built assets (mainly late design and early construction stages). Some analyzing and realizing BIM uses (e.g., simulating, and controlling) are still applied at a lower level, mainly during the operation stage. Moreover, the experts revealed the potential of BIM usage in facility management, parametric/ algorithmic associations, and energy simulations, and on-site construction support, according to the local market's tendency and orientation in the upcoming few years.

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