Underlying Factors and Strategies for Organizational BIM Capabilities

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Building information modeling (BIM) has a significant role in the architecture, engineering, construction, and operation (AECO) industries. Most BIM benefits have not been grasped due to the lack of organizational BIM capabilities (OBIMCs). Accordingly, organizations must develop intuitive strategies to support BIM implementation and to fulfill the promised benefits.

Keywords: building information modeling (BIM) ; organizational BIM ; BIM capabilities ; automation ; building technology ; construction management

1. Introduction

Due to the complicated nature of construction projects, decision-makers in the architecture, engineering, construction, and operation (AECO) industries are encouraged to adopt building information modeling (BIM). BIM is a digital version of a facility's physical and functional characteristics that enables architects, engineers, and other construction professionals to plan, design, and construct a structure or building [1]. BIM has played an essential role in improving the design of the demolition phases of construction projects [2]. Significant capabilities of BIM can ease the decision-making process and can improve the productivity between all involved components in construction projects, ultimately improving the efficiency of the whole construction supply chain [2]. In the United States, BIM has been embraced by over 98 percent of large architecture organizations [3]. In comparison, over 30 percent of smaller organizations use BIM for some modeling and documentation [3]. The design sector as a whole has adopted BIM at a rate of about 80% [3]. Similar tendencies may be seen in industrialized countries such as the United Kingdom [4]. However, despite its popularity, several economies have been slow to implement BIM due to many problems [5].

Despite BIM's promising capabilities, this rise in utilizing BIM in construction projects encompasses a broad spectrum of usage. According to a recent survey, most BIM uses are limited to visualization or idea development models, and only a few professionals take advantage of fully integrated and incompatible BIM systems [6]. Furthermore, in many developing countries, BIM is mainly employed for low-maturity tasks such as visualization and clash detection [7][8]. As a result, many efforts have been made in recent years to investigate the obstacles to achieving the required organizational BIM capabilities (OBIMC) [4][9]. According to prior works, in the various AECO environments, attitudes and technological barriers, as well as management strategies and environmental constraints, differ from one another [4]. As a result, there appears to be no clear path to BIM adoption, and integrating BIM with various contexts is a continuous endeavor [10].

2. Capability Factors Influencing OBIMC

One of the major challenges to implementing BIM is the diversity of working conditions in the construction industry, engaging a variety of concerns such as real-time progress, cost management, and construction safety [11][12]. According to Succar et al. [13], the traditional education system has focused on acquiring theoretical knowledge regardless of whether it is a degree-based educational system. A person's attitude toward technology is the key determinant of their risk acceptance level. Consequently, many professionals working in the AECO industry, particularly in developing countries, express concerns about BIM implementation. BIM is often regarded as a "disruptive technology" that challenges traditional construction methods. In the meantime, a person's skill level in BIM is determined by the personal traits, professional knowledge, and technical ability required to facilitate the integration of BIM-related activities in a project or generate BIM-related outputs, regardless of their employment. Individuals might be professionals, tradespeople, scholars, or learners in any field. Additionally, the absence of collaboration between professionals and organizations has resulted in a lack of understanding of the BIM procedure and challenges with compatibility [6]. Most frameworks for BIM adoption have not addressed the human behaviors and organizational factors that influence BIM performance, even though these factors are important [14].

Furthermore, recent work found that staff experience significantly influences BIM implementation success. Moreover, educational qualities and individual skills are essential determinants of BIM adoption [15]. Indeed, previous organizational BIM experience and contractor and consultant proper selection policies were underlined as crucial aspects in the broad application of BIM. Particularly, according to Chen et al. [16], most existing frameworks for assessing capability highly rely on process maturity or the presence of technological infrastructure rather than previously identified indicators. It is worth mentioning that in the pre-qualifying and selection process, prior experience with BIM has been recognized as the most significant qualification.

Due to the sophisticated nature of the BIM process, the deployment of professional technical abilities is needed. Certainly, selecting and applying proper hardware and software and continuous monitoring and technical support require hiring Information technology (IT) professionals. Generally, the variety of BIM software used at the project scale contributes to data interoperability issues. As a result, professional assistance in solving probable technical issues is a requirement to speed up BIM adoption. Consequently, the amount of assistance a professional receives in selecting hardware/software and implementing BIM may be an indicator of the quality of their competence. On the contrary, BIM implementation can be hindered by the lack of human resources [5][8]. Nevertheless, Qin et al. [17] stated that the number of BIM experts and technical employees had an insignificant impact on BIM adoption, significantly influencing company workflow and the human aspect of the implementation.

Leaders knowledgeable about BIM can lead their teams to analyze unverified design data and to verify the shared data within the project team. Additionally, their other role is to create an atmosphere where the impact of probable modification has been minimized. Further, influence and motivation may be valuable in aiding BIM leaders in developing a cooperative work environment and overcoming obstacles to data sharing. A collaborative approach can help overcome negative attitudes toward BIM adoption and motivate subordinates to adopt BIM by demonstrating its benefits [18][19]. Positive attitudes toward new technologies are also crucial to fostering an organizational learning culture and can enhance learner acceptance which is a key component of successful technology adoption [20]. Consequently, the adoption of new and necessary insights about the essential abilities and values of BIM can be facilitated by a positive corporate culture.

Another crucial element for actual BIM adoption is utility acceptance. A recent work by Lee et al. [21] evaluated organizational acceptability by identifying the processes through which organizations agreed to implement, adopt, or encourage other organizations to adopt BIM. Willingness to expend time and effort in learning is the first step in learning BIM and, ultimately, BIM adoption. All organization members must be informed of the BIM applications, even if they do not fully comprehend the technical design processes involved. The information can enable organizations to create meaningful data that can assist them in their project duties. Unfortunately, organizational models, processes, roles, and work content are difficult to change, making BIM adoption more difficult. The inherent difficulties hinder BIM implementation in altering organizational models, processes, and roles in the AECO industry. The BIM process offers limited advantages to current organizational models and workflows, often involving process-related and organizational task adjustments during the integration phase [22].

The commitment of senior management is vital to guarantee the success of BIM adoption [21]. Technology-related challenges are addressed most effectively by high-ranking authorities, introducing changes to job profiles and duties, and resolving conflicts of interest. A senior executive should be educated on the benefits and hazards of any new technology before deploying it. If the corporate policy supports BIM, enabling organizational adoption becomes easier. In this regard, the work by Succar et al. [13] demonstrated the importance of senior management support in promoting BIM adoption through employee training.

Creating, maintaining, and disseminating construction data is described by BIM standards, which are an essential component of BIM implementation. Therefore, developing open and standardized systems for data and information throughout a project's lifecycle is vital. To accomplish so, governments publish documents to ensure the implementation of BIM in public projects is consistent. Although such guidelines are commonly used in public projects, private organizations can create standards incorporated into most industry organizations. These steps include planning for BIM implementation, establishing information exchange-capable systems; creating modeling standards, guidelines, and effective practices; and promoting, communicating, and explaining BIM advantages to other parties [23].

As another important factor, financial support for setup costs has been highly considered for BIM implementation, specifically in small and medium-sized enterprises (SMEs). Senior management must be ready to support the sustained development of BIM financially. BIM projects often involve several offices and locations with teams operating centralized sites and practicing their duties [6]. Moreover, due to technological challenges related to BIM-authoring software, BIM leaders need to develop and maintain strategic partnerships with their BIM-authoring software suppliers, consultants, contractors, and the external BIM community. In order to ensure the successful implementation of change, a strategic policy is required. It can be achieved by gradually engaging members in change activities, such as decision-making and planning, over time. Furthermore, stakeholders need an appropriate plan to use their accumulated information and lessons. Change management is essential when accepting, authorizing, and verifying BIM-based information [19]. Overall, the ability to successfully employ BIM is correlated with an organization's investment in BIM research and development [24].

BIM comprises three distinct elements: software, hardware, and data/networks. Through a BIM tool (BIM Stage 1 requirement), you can transfer from drawing-based workflows to object-based workflows, which are organized around resources, processes/workflows, products, and leadership. The model-based collaboration includes working together and sharing database information (BIM Stage 2) [25]. BIM capabilities within organizations may be affected greatly by this. Organizations can assess their performance through self-assessment, using suggested standards for internal benchmarking, and assessing their suitability for tendering for projects based on the weighting of qualifying conditions [24][26][27]. In this way, organizations can observe their BIM capabilities and areas that need enhancement. One major barrier to BIM adoption is implementation costs. Identifying what areas of BIM capability building to focus on is crucial in optimizing adoption [28]. Organizations can enhance their BIM capabilities by benchmarking and focusing on specific BIM targets.

Finally, BIM capability evaluation is vitally important when considering the contribution of BIM to previous successful projects. BIM performance and capabilities are a key part of BIM Execution Plans (BEPs). As a result, different BIM capability elements within an organization can be evaluated according to their influence on the different factors involved in successful BIM delivery. To ensure the success of a project, it is necessary to recognize the importance of prioritizing the standard process of assessing BIM capability based on its contribution to project success through standards, such as the Publicly Available Specifications (PAS) established by the UK government [27].

3. Strategies for Improving OBIMC

3.1. Standardization

As part of its ongoing effort to foster the development of integrated teams, the AECO firm has formed a broad range of technological procedures, including interoperable programs and means for sharing information. In order to achieve greater success during the implementation of BIM, project teams should communicate effectively and building components should be standardized [29]. Standardizing BIM guidelines and processes are important to guarantee successful and effective implementation [30]. Furthermore, the advancement of BIM-related technical procedures and standards can facilitate a successful cooperative environment. Consequently, the organization's senior management should implement a clear operational strategy for improving BIM capabilities.

3.2. Policy

Among factors affecting BIM adoption, BIM policy plays a crucial role. The AECO industry still relies on traditional working techniques, as evidenced by an evaluation of current procedures and survey results. Therefore, a BIM implementation policy must be formed at macro- and micro-adoption levels to guarantee successful implementation [29]. This requires the introduction of BIM into the contractual environment gradually. BIM can also be applied to construction projects by adopting policies that lead to clearer visions regarding project delivery methods, the excellence of processes, and the consistency of information across AECO organizations [31]. One perspective suggests that policy is a fundamental element of BIM operations [24]. Based on this perspective, organizations must establish internal BIM policies to enhance their BIM capabilities.

3.3. Training and Education

Different ethnic and cultural backgrounds of industry stakeholders greatly affect their experiences with BIM. Therefore, AECO organizations should implement BIM learning curves tailored to each stakeholder. In addition, comprehensive and well-developed education and training programs help employees upskill and increase their knowledge of BIM technologies and concepts [30]. Major education and training groups include individual characteristics, training intervention design and delivery, and workplace context factors [32]. Furthermore, the evaluation should also be based on the trainee's learning outcomes, behavioral reactions, expectations of what the training programs expect to accomplish, and the extent to which work performance increases due to new knowledge and skills [33]. A comprehensive training and education program is essential to meeting end-user demands and ensuring continuous developments in products and services [34]. Moreover, BIM is a relatively new technology, which can cause varying degrees of expertise among industry participants, directing to results of varying quality. To increase BIM performance, vendors and organizations must collaborate on making learning and training easier [35]. Additionally, training programs can be tailored to meet different preferences, including global and standard requirements and specific and advanced requirements [36].

3.4. Motivation

Adriaanse et al. [37] noted the value of personal and external motivation to embrace new information and communication technology, such as BIM, in the AECO environment. Individual motivation is defined as the level of curiosity and willingness to employ new technologies. In construction, motivation comes from the perceived upsides and downsides of different technology applications in meeting a short deadline and working in a short-term relationship [38]. External motivators include contractual agreements for BIM and the presence of stakeholders seeking the technology [37]. These demonstrate the influence of competitors, collaborators, and other stakeholders within the AECO industry. Establishing a learning-friendly environment is also important for BIM adoption to succeed. A learning-oriented organization builds a culture of experimentation and risk-taking within the organization so everyone can grow, develop, and learn from it [39]. The processes of deconstruction (new methods of accomplishing a task) and reconstruction (correcting a mistake) that are involved during BIM organizational transformation are reflective [40]. Through a learning-by-doing approach, employees can easily realize BIM implementation proficiencies [22].

3.5. Cultural Readiness

Previous explanations mentioned that some might oppose the introduction of BIM. As a solution, communicating effectively allows people to be engaged in the employment of BIM while instantaneously becoming familiar with organizational procedures, expectations, and goals. In order to avoid resentment among employees, organizations with robust change management programs are more likely to adopt new strategies [32]. Organizational cultures (OCU) that are open to innovation and adhere to consistent values and objectives are most likely to successfully adopt new initiatives [22]. Potential clients must adopt a positive mindset before implementing BIM. This demonstrates that controlling the organization’s readiness for change is key to successful implementation [41]. It is also imperative that the management includes users as early as possible. BIM users should be consulted to gather their requirements, remarks, responses, and approvals [22]. To drive consensus throughout the implementation process, leaders need to recognize and investigate the causes of objections to BIM tools and systems [21]. In addition, change agents play a key role in advancing skills and abilities that contribute to changing behavior, attitudes, and behaviors [13].

3.6. Network Relationships

Organizations driving the implementation process of IT systems, systems integration, and software must collaborate with consultants, supply chain partners, vendors, and internal stakeholders to resolve implementation problems [22]. In most AECO organizations, particularly SMEs, in-house capability or sources are insufficient to implement BIM. That is why external consultants and software suppliers are crucial. Sometimes software suppliers perform the role of consultants. Establishing long-term relationships with suppliers and external partners is imperative during BIM implementation. The ability to foster a network of organizations with a wealth of BIM knowledge offers the opportunity to achieve knowledge in BIM applications [2].

3.7. Management of Processes and Performance

The BIM maturity model can assist businesses in understanding the BIM implementation processes. In addition to determining the maturity level of an organization, these tools can serve many other purposes, such as assessing readiness and capability and establishing internal benchmarking. Regardless of their breadth of application, maturity models and tools that clearly described phases can provide a roadmap for organizations to ascend to higher maturity levels. Generally, there are three main types of maturity evaluations: project-oriented, such as the virtual design and construction scorecard; organizational-oriented, such as the BIM maturity measurement [25]; and macro-level maturity models [42]. Considering this variety, objectives should be determined prior to selecting BIM tools. In addition to preparing a maturity model and examining BIM-enabled processes and components, data collection methods and tools should be used to monitor BIM implementation. Managers and leaders of BIM can then use the information collected from performance evaluations to verify that the BIM practices comply with the defined policies and plans.

Comparing BIM performance across organizations can be accomplished with external benchmarking tools and data [43]. This provides the information that organizations need to execute long-term improvement plans. However, adopting BIM successfully relies heavily on ingrained, tacit knowledge, which makes duplicate tasks more challenging. Knowledge can be effectively transferred across organizations via the transmission of individuals between organizations, the creation of industry networks, or the replication of practices by regular and systematic observation [44]. AECO organizations should carefully review their circumstances to determine the best methods to apply to their business operations. There is no single, universal way to implement BIM [2].

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