A comparative analysis of BIM standards and guidelines between UK and USA

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Abstract. Architectural projects, carried out by the public sector in Iraq using traditional methods suffer from lots of problems such as the inaccurate estimation of time and cost, and the poor cooperation among project team members. To tackle these problems, it is important to benefit from the experiences of the pioneering countries in this field such as the UK and USA. These countries kept pace with digital development and established new systems in construction, namely Building Information Modelling (BIM). This paper investigates the similarities and differences between the BIM standards and guidelines in the UK and USA. The findings of this comparative analysis can build a knowledge base for establishing BIM standards in Iraq. The paper identified the similar aspects to be adopted in the Iraqi standard of BIM, such as the design techniques, the designers' roles and responsibilities, and some aspects in the information management. In addition, their differences are distinguished, which indicate the specificity of BIM application in each country. For the different aspects, the Iraqi BIM standard can either adopt the descriptions of the UK or USA such as the method of structuring design data, or reflect the Iraqi specificity such as the national library of BIM.

1. Introduction
In the era of digital technology, Building Information Modelling (BIM) is a new approach in a building life cycle, from design phases to construction, operation, and maintenance. The construction sector has witnessed a digital transformation through the application of BIM in the field of building engineering. Designers can generate a virtual digital model of building that supports all design stages and allows for better analysis and control of manual processes. The digitally designed models contain the accurate engineering data necessary to support work activities in the construction, manufacturing, and installation phases and through which building, operation, and maintenance objectives are achieved. Architectural and engineering studies have addressed the definition of BIM from many aspects of engineering work. The BIM model is defined by the National BIM Standard in the USA (NBIMS), as a “digital representation of physical and functional characteristics of a facility”. It is considered as a source of shared knowledge and information about a building [1]. It is a platform to support the collaboration and integration in the working environments of building project management [2]. BIM is facilitated by digital techniques to describe tools and processes about the building planning, design, construction and operation. It is a methodology for a digital format management of building design and project data during the building's life cycle [3]. This modelling technology has a set of processes to generate, communicate, and evaluate building models. BIM models are building components (objects) that are represented digitally to incorporate computable graphic, data attributes, and parametric rules that enable them to be handled in an intelligent manner [4].
In the next sections, the importance of BIM in building design and construction was identified. Then the research problem and objective were outlined to highlight the requirements of BIM application in Iraq. The research methodology was to determine the most important aspects of BIM, to conduct a comparative analysis between the standards and guidelines of BIM in the UK and USA, and to review the results and conclusions. Figure 1 shows the structure of the research.

![Diagram of research structure]

**Figure 1.** The structure of the research.

2. The Importance of BIM in Architectural Practice

The building delivery process has traditionally been fragmented, depending on paper-based approach of communication. Paper documents have a lot of errors and omissions resulting in unanticipated costs, delays, and legal actions between the project team parties. To tackle such problems, alternative organizational methods such as the (design-build) has been suggested as one of the BIM implementation methods [5]. The importance of BIM in architectural practice can be summarised as follows:

2.1. Level of details

BIM is the solution developed to address problems in traditional systems, including poor detailed documentation. In traditional CAD methods, data are only graphical entities such as lines and arcs, unlike the intelligent contextual semantic models of BIM models such as walls and columns [6]. Also, the traditional CAD system includes non-parametric tools, unlike the BIM system, in which the editing in one of the parametric variables is transmitted to others leading to updated model [7].

2.2. Level of coordination between the designs of the engineering disciplines

The collaboration and coordination of design teams in architectural projects is one of the challenges. Comparing varied 2D drawings is a commonly practiced process for checking and detecting issues. On the other hand, the use of BIM model brings the plans of different disciplines together to detect the clashes [8].
2.3. Level of communication and participation
The BIM system also addressed the problem of single linear workflow among designers in traditional practice. Design teams of different disciplines work in isolation from each other, lack of communication during the preparation of design. Figure 2 shows the differences between the linear workflow in the traditional CAD system and the concurrent workflow in BIM [9].

![Figure 2. The difference in the project workflow between the BIM system and the traditional CAD method [9].](image)

2.4. Level of database
In the traditional CAD method, there was no reliable digital database for the various operations of the project. There is a loss of data after the completion of the project therefore, it cannot be used in the operation and maintenance stages. In contrast, the BIM provides a virtual 3D model of the building to be a single source that contains all the information and documents of the project in one three-dimensional model and within a synchronized database [7].

2.5. Level of design complexity
BIM also addresses complex design problems to find solutions to them through technologies that enable alternative solutions to achieve several design goals. For example, the size and complexity of the Shanghai Tower have created many challenges, but BIM has made the construction process easier and faster by discovering clashes between different models, and removing the potential risks. In addition, BIM model is able to simulate the main difficulties and continuously revealing the relationships between construction processes and their time sequences, as shown in figure 3 [10].

![Figure 3. The work stages of the Shanghai Tower using the BIM system [10].](image)

Also, in the Foundation Louis Vuitton project, the use of the BIM system helped to eliminate many problems that typically arise from poor communication and technological regulation. Parametric
modelling was combined with advanced automated manufacturing processes to produce components and to control the quality that promoted the entire production chain, as shown in figure 4 [4].

![Figure 4. The Foundation Louis Vuitton project according to BIM [4].](image)

2.6. Level of time scheduling
One of the advantages of BIM in addressing the traditional CAD problems is to provide a visualization of the execution sequence and schedule of construction work stages, which cannot be achieved through 2D graphics [11].

2.7. Level of cost estimation
The BIM tools also allows for automatic data analysis, quantification, and accurate cost calculation. This eliminates the error-prone process of manually formatting spreadsheets [12].

2.8. Level of improving energy efficiency and sustainability
Sustainable construction has faced many global challenges, including the inefficiency in the entire life-cycle data arrangement and in sharing data analysis with project participants. BIM can manage and store the data of building project related to sustainable construction such as energy consumption and day-lighting simulation and offer workflow data in detail during construction operation. Thus, BIM users can achieve the goals of energy-saving and improve the sustainable development [13].

Built on the aforementioned, the importance of adopting BIM in the architectural practice across the world is evident. This calls for the need to adopt it in Iraq to benefit from its advantages and to address the problems that the building and construction sector suffers from.

3. Research problem, Objectives and Methodology
The research problem was to identify the requirements of BIM application in Iraq. Based on a thorough review of previous studies, it can be said that there is a lack of a clear vision on the similar and different aspects of BIM in the standards and guidelines of pioneering countries such as the UK and USA. The results of a comparative analysis can be adopted as a knowledge base for establishing the standards and guidelines of BIM application in Iraq in the future, to contribute in solving some of the problems that the construction and reconstruction sector in Iraq suffers from.

The research aimed to build a database for Iraqi BIM standards and guidelines based on the relevant standards in the developed countries such as the UK and USA.

The research methodology included the following steps:
- To identify the most important aspects in the application of BIM in architectural practice.
- To investigate these aspects in BIM standards and guidelines of the UK and USA and to conduct a comparative analysis between them.
- To conclude the similarities and differences in BIM aspects in the BIM standards and guidelines of the UK and USA. Similar specifications can be adopted in the Iraqi standards and
guidelines of BIM, and the different specifications that require a local specificity in their definition can be investigated in future studies.

4. The main aspects of BIM

The paper investigated many studies on the theory and practices of BIM such as, [1], [4], [14], [15], [16] and [17]. Based on them, the most important aspects in the application of BIM can be categorised in its work strategy, utilizing of information, and the participating parties.

4.1. Work strategy in BIM

The work strategy in BIM can be defined in terms of many aspects, such as: the dimensions of BIM and the tasks performed in each dimension, which vary from (3D to 7D). The 3D dimension includes the three-dimensional components of buildings, in which the object modelling is based on the relationships (spatial engineering) and properties (physical and mechanical) [15]. The 4D model is defined as creating a 3D model with time scheduling attached to it. It provides users with a virtual simulation of project construction time and a visualization of the path of various construction activities, and allow users to comment on them in a proactive manner and on time. 5D BIM model is defined as the model in which the 3D model is linked to both time schedule and cost estimation using an appropriate program [16]. The 6D model represents the sustainability model and the 7D model is concerned with operation and maintenance as clarified in figure 5 [17].

Other aspects are the timing of the use of BIM in the building life cycle which ranges from (design, construction, operation, and maintenance phase), and the design techniques employed in the BIM system which in turn range from many techniques such as parametric techniques, simulation, virtual reality, etc.

4.2. Utilizing of information in BIM

The use of information in BIM is subjected to varied data processing methods and different computerised techniques. The date processing includes several aspects that define the methods of structuring information into various levels of BIM, the methods of storing design database in BIM - BIM libraries, the methods of coordinating and classifying building information in BIM, and the methods of representing design information in BIM. The digital techniques that support the use of information in BIM can be defined in terms of the method of a digital collection of information in BIM namely Construction Operations Building Information Exchange (COBie)⁴, the methods of digital storing of information in BIM and the methods of digital security of computer systems and design information in BIM, the methods of digital organization for managing and sharing information in BIM, and the methods of integration and interoperability in the digital representation of information in BIM [18].

4.3. The participating parties in BIM

There are different participating parties in BIM. The roles and responsibilities of the participating team members can be architects, engineers, owner, contractor, information manager, and BIM director. In addition, there are varied methods of communication and sharing among team members such as the content of legal contracts in BIM, the place and time of communication among the participating

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⁴ COBie is a digital standard technology to collect information required during the design and construction process, to be handed over to the owner to operate and maintain the building. The system is characterized by classification and structuring of information. It provides a framework for storing information, and for retrospective exchange it in the database.
parties in BIM, the modes of communication and sharing, and the patterns of design workflow among the participating parties in BIM [5], [19], [20], [21].

5. A Comparative Analysis of BIM Standards and Guidelines Between UK and USA
The authors did a comprehensive review of 40 BIM standards and guidelines, 14 of them issued by the institutions in the United Kingdom and 26 issued by the institutions in the United States of America [22]. They have been analysed to identify the similarities and differences in their descriptions of the main aspects of BIM specified in section 4. The comparative analysis focused on the knowledge content in the definition of each aspect of BIM in the standards and guidelines of these two countries. The results obtained from the comparison range between the existence of similarities in the content description of a BIM aspect, or the differences in the content description of a BIM aspect. In case of the differences, they can be total differences or partial differences at the level of titles, details or the laws in contracts.

6. Discussion of Findings
The similarities and differences in the standards and guidelines of BIM between the UK and the USA can be summarised as follows:
6.1. The similar aspects of BIM
- The standards and guidelines of the two countries are identical in their content description of BIM aspects such as the timing of using BIM in the construction, operation, and maintenance phases. In addition, there are similarities in the definition of design techniques of BIM such as parametric modeling, virtual reality, time scheduling simulation, structural analysis, coordination and conflict detection. Also, same descriptions of BIM aspects are found in BIM dimensions (3D, 4D, 5D), digital information collection/COBie methods, digital information security organization methods of BIM, integration and interoperability in the digital representation of information in BIM, communication and sharing methods, and workflow methodology among design teams. According to that, the descriptions of these aspects can be adopted in the Iraqi standard and guidelines of BIM.

- There is a high similarity in the content description of digital organization methods for managing and exchanging information in BIM between the standards of the two countries. Therefore, its descriptions can be adopted in the Iraqi standard of BIM.

6.2. The varied aspects of BIM
The content descriptions of BIM aspects are varied in the standards and guidelines of the UK and USA. They are as follows:
- Total difference: From the comparative analysis, the total difference in the content at the level of titles and details can be found in the definitions of information classification system, namely the Uniclassb and OmniClassc systems. Accordingly, one of the above classification methods can be adopted in the Iraqi standard of BIM or a special classification for Iraq can be suggested.

- Partial difference: at the comprehensive level, the differences between the standards and guidelines of the UK and the USA is not fully.

- The content descriptions of the timing of using BIM at the design stages vary in terms of their details between the BIM standards in the UK and USA. The BIM standards of the UK determine the path of the design process within a specific methodology without deviating

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b Uniclass, is the UK Building Information Classification System which provide a set of hierarchical tables for identifying and categorizing everything from site (at the macro level) to floor tiles (at the micro level) [23].
c OmniClass, is a Building Information Classification System in the USA and especially in North America starting from material organization, catalog organization, product data, and project information providing a classification structure for electronic databases [24].
from the set plan and within levels ranging from (0,1,2,3). On the other hand, the USA standards give the designer freedom to model according to the need for each stage and according to five levels namely the Level of Details or the Level of Development LOD 100-500. Accordingly, for this aspect, the UK standards can be adopted in the Iraqi standard.

- Other partial difference can be found in the content description of the two countries' standards regarding the simulation of environmental analysis. They vary in terms of the data adopted in the environmental analysis and according to the geographical context of each region. In addition, there is a difference in the details of BIM 6D or 7D dimensions of sustainability depending on each country criteria for the classification of the degree of obtaining green buildings. This indicates the necessity for building Iraqi database for environmental analysis taking into consideration the Iraqi codes of elements and materials to be used in the design of sustainable buildings. Also, to facilitate the use of BIM for sustainable design, it is necessary to prepare the Iraqi standard for assessing the degree of building sustainability by the research centers or universities.

- The content descriptions of the two countries' standards differ in their definition of the 6D and 7D models, as the UK standards define the 6D model for operation and maintenance of building and the 7D model for sustainability. The US standards define the 6D model as the sustainability model and the 7D model as the operation and maintenance model. Accordingly, descriptions of one of them can be adopted in the Iraqi standard. The content descriptions of the design data structuring methods at the various levels of the BIM varies between the standards of the two countries. Since the standards of the UK and USA clarify the methodology of work and the steps required at each stage, it is therefore possible to adopt one of them in the Iraqi standard.

- The results indicated the variance in the naming and terminology used in the two countries' standards. Thus, it is possible to adopt specific naming and terminology in the Iraqi standard for BIM.

- There is a variance at the level of details in the content descriptions of the methods of storing the design database in BIM / BIM libraries between the standards of the two countries. This result indicates the necessity for building Iraqi database to represent the national library according to the Iraqi standard of BIM.

- The methods of digital storing of information differ in the two countries' standards and guidelines. The UK standards are characterized by a full explanation of the methodology of storing information, which makes it possible to adopt their descriptions in the Iraqi standard of BIM.

- There is a partial difference at the level of details between the UK and US standards in their focus of the roles and responsibilities of the participating parties. At the same time they are similar in defining the roles and responsibilities of the participants, which makes it possible to be adopted in the Iraqi standard of BIM.

- There are differences in the content descriptions of BIM standards and guidelines in the UK and USA in terms of the information of contracts and laws. According to that, Iraqi laws can be adopted when concluding agreements between the contractor and the employer, to define the requirements and objectives of modeling, the required processes, and the workflow stages of BIM.
7. Conclusions
The paper conducted a comparative analysis between BIM Standards and Guidelines in UK and USA. The results of the analysis revealed the similarities and differences in the descriptions of BIM standards and guidelines of these two countries. The similar aspects of BIM that can be adopted in the Iraqi standards and guidelines of BIM are the timing of using BIM in the construction, operation, and maintenance phase, the design techniques, as well as the dimensions of BIM (3D, 4D, 5D). In addition, there are similar methods of digital organization for information management and exchange, similar methods of a digital collection of information / COBie, and similar methods of digital organization for information security. Other similar aspects are the integration and interoperability in a digital representation of information in BIM, the communication and sharing methods, and the design team workflow methodology.

On the other hand, there are varied aspects in the BIM standards and guidelines between UK and USA. There is a difference in the timing of using BIM in the design stages. As the UK standards determine the design process in a specific sequence within four levels of (0,1,2,3). Contrary to the standards of USA, which give flexibility in modeling according to the need within five levels of details (LOD 100 to 500). Also, the UK standards define the 6D model for operation and maintenance of building, and the 7D model for sustainability, while the USA standards define the 6D model as the sustainability model and the 7D model as the operation and maintenance model. In addition, there is a variation in the classification systems of building information, as the UK adopts the Uniclass and the USA adopts the OmniClass. For these varied aspects, the Iraqi standard and guidelines of BIM can adopt the descriptions of one of the two countries.

Furthermore, the results distinguished the varied aspects that need to reflect the specialty of each country such as the classification of the degree of obtaining green buildings, the methods of structuring the design data, the naming and terminology of files, storing the design database in BIM libraries, as well as the contracts subject to the building laws of each country. These aspects require to be defined in compatible with the specialty of Iraq.

However, the paper did not cover in detail important aspects necessary for the implementation of BIM in Iraq such as the BIM library and sustainability standards of BIM which can be adopted in future research. Based on the aforementioned, table 1 provides a summary of the conclusion as a future vision for implementing BIM in Iraq.

| Identical aspects of in the UK and USA which can adopted in the Iraqi standard of BIM. | The timing of using BIM at: |
|---|---|
| | -The construction stage |
| | -Operation and maintenance stage |
| The design techniques used in the design processes are: | -Parametric modeling |
| | -Algorithms |
| | -Virtual Reality |
| | -Simulation |
| | -Coordination and clash detection |
| BIM dimension models (3D, 4D, 5D) | Information Collection System. COBie |
| | Integration and information interoperability. |
| | Digital organization of information security |
| | Information management systems and their digital exchange between the participating parties on the web |
The CDE Common Data Environment is a web-based platform and central storage base for information.

Methods of communication and sharing

Roles and responsibilities for the participants

Workflow between the design team

**Different aspects of BIM. It is possible to adopt one of the options in the UK or USA standards.**

- **Adopting the design data structuring system**
  - Either according to UK standards from level 0 to level 3
  - Or according to US standards LOD 100-500

- **Adopting a specific coordination and classification system for information**
  - Either according to the UK standard: Uniclass
  - Or according to the American standard: OmniClass

- **The use of BIM is at the design stage**
  - UK Standards – Specific sequence in using standards and working levels from (0,1,2,3)
  - American Standards - Freedom to choose the sequence of modeling standards within the LOD100-500 levels

- **6D,7D models**
  - According to the UK standards, the 6D is the operation and maintenance model, and the 7D is the sustainability model
  - According to the USA standards, the 6D is the sustainability model, and the 7D is the operation and maintenance model

**Different aspects of BIM that can be set up to give it a local specificity**

- Preparing the BIM National Library according to approved Iraqi codes, to contain elements, materials, and shapes.
- Preparing a method for representing the design information in terms of terminology and naming of files in a common language
- Preparing sustainability standards in consistent with the Iraqi specifications that include the requirements to be implemented in the building according to its functions, and the points that are attained according to the standard
- Information content in legal contracts to include building codes in Iraq

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