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BIM, as a digital process for sustainable Architecture

Ons NAJJAR MANSOUR
Dr in Architecture (PhD), Professor at Institute of technology, urbanism, environment and building ISTEUB (urbanism Department),
Onsnajjarmansour@gmail.com

Raja Gzara
Architect, Architecture lecturer University Ibn Khouldoun,
BIM coordinator AMA Group
gzara.raja@gmail.com

Abstract:
The Building Information Modeling (BIM) has become increasingly important for the development of construction sector all over the world. States are implementing Policies and strategies to accelerate the spread of uses and practices. The BIM is identified as a digital process, used to perform the collaboration during the life cycle of a project. According to BIM Dimensions, the 6D refers to the sustainability and environmental Data. Nowadays, the adoption of BIM very signifyingly from one country to another depending on market maturity, Economics factors, Project complexity Regulatory environment and much more. BIM in UK, Singapore, Norway, UAE is mandatory for public projects, some others country just encourage and promote the use of BIM. The implementation strategy involved a collaboration effort from Process, Policies, Software (SUCCAR.2007).
The aim of this paper is to highlight the importance of introducing BIM at multiple levels (Macro, Mezo and Micro Levels) and to offer the opportunities to perform the process for a sustainable architecture with the university contribution.
Analyzing case studies form the leading countries in BIM use such as UK, Netherland, France… can indeed help develop specific type of thinking and skills to get inspired to conduct a process to implement BIM within other countries
The question is how can we enlarge the BIM use in order to develop a sustainable architecture in particular for Arid and Semi-Arid states? And what is the role of university to contribute to the widespread adoption of BIM practices.

Key words: Digital, Process, Strategy, Sustainable, Collaboration

Introduction:

BIM is a process for creating and managing information on a construction project throughout the whole life cycle. It concerns all stages: Programming, Design, Construction and Facility management of a project. The use of BIM process can be categorized into

different dimensions, each representing a level of detail needed to extract useful information for energy consumption, facility management, health and security… This process is becoming a factor of development in the AEC (Architecture, engineering and construction) using recent technology development and a smart way to use information.

Building information management (BIM) is "the use of virtual building information models to develop building design solutions, to design documentation, and to analyze construction processes" (J. Riskus,2007).

BIM offers a variety of useful information that can develop a better design solution, multiple working processes and a flexibility in exchanging information. Based on the use of digital tools, the BIM process allows you to optimize the time of designing in a collaborative way, and many more. Depending on BIM used Dimensions, (referring to the levels of information in a given BIM data used for BIM), the process makes way for better cost, time and facility management as well as sustainable development. In this case the sustainable development refers to incorporating environmentally friendly and socially responsible practices throughout the entire lifecycle of a building project.

The BIM Process is based on the management of the information that have been required at the start of the project. The Digital model is the main source of information to be shared to ensure a collaborative working way, without time loss or multiple reuse of the information. A digital model refers to a 3D computer-based representation of an object, building, urban site, infrastructure created using BIM Process. It's a virtual representation that can be used for various purposes, including visualization, analysis, simulation, and communication.

"The adoption of technologies, especially BIM and building management systems, provides a consistent set of solutions beyond design and construction by supporting the collaborative creation, management, dissemination, and use of information through the entire product and project lifecycle. Furthermore, this provides a new approach to processes through more effective integration of people, processes, business systems, and information" (Shen et al, 2009).

The use of BIM has an important impact on architectural practice, it is a solution to reduce the gap between designed and constructed building, as it raises new ways and processes of delivering designs, construction and facilities management services. It can also impact the design by adopting a sustainable vision of a project and contribute to estimate the energy efficiency in a building. Using digital tools, we can at an early stage be aware of the energy consumption and can process to a modification to improve better practices. These digital tools determine the impact of the location of a project, the orientation of the building and the path of the sun.

Problematic:

The aim of this paper is to highlight the importance of introducing the digital tool for architecture design at multiple levels to offer a sustainable way to manage projects especially on arid and semi-arid site in Africa. As a process, BIM offers the opportunity for all construction's professionals: Architects, Engineers and Constructors, to use it and develop the ability to work more efficiently and effectively moving forward.

The use of BIM has brought various challenges and issues among all the AEC Contributor. How can BIM improve the design process in particular for arid and semi-arid? And how can it be enlarged and generalized in order to offer a sustainable architecture?

Materials and methods:

This research will be conducted on three steps:

1. The first step, will focus on defining the BIM as a collaborative process in the AEC industries. For that, we will highlight the importance of adopting BIM process as a working way able to manage project on a sustainable objective.
2. The second step, based on analyzing case studies of BIM use in leading countries will provide a valuable approach to adapt challenges, opportunities and best practices to the scale of arid and semi-arid countries. We will focus on the implication of several structure to improve BIM uses and will develop a specialized thinking regarding the importance of a collaborative implication of the governments, the AEC industries and the university to introduce the BIM.
3. The third step, will focus on the fact that the involvement of the government is not enough if it is not supported by the training strategy and the implication of several structure to conduct the digital evolution to the end steps. The university seems to be a part of the triad that should include also the mandatory of using BIM for public projects, and the need to state employee training. As architects and lecturer at university, we estimate that we should focus on introducing the BIM process at the university level, and consider also the importance of policies and implementation strategy.

Results and discussions:

1. BIM as a collaborative process for sustainable design

The construction industry is facing new challenges regarding the need to reduce building costs and to be more sustainable using digitalization. As per the complexity of new projects and the need to collaborate in a way to proceed on the execution as planned, the use of BIM process transformed the way construction and design projects are approached, offering numerous benefits to various contributors. BIM is particularly advantageous for managing projects due to its ability to coordinate multiple disciplines before starting the construction. It also provides a visual and data-rich platform that enhances communication among project stakeholders, enabling better understanding, collaboration, and decision-making.

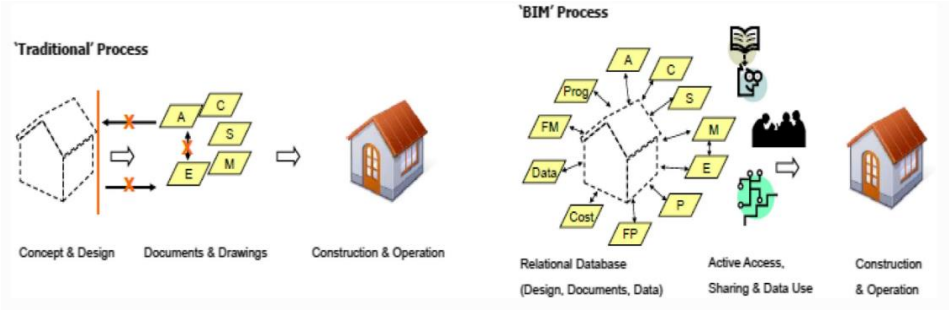

Fig 1 : ILLUSTRATION OF TRADITIONAL PROCESS AND BIM PROCESS

Building information modeling is a process of creating and managing information during a life cycle of the building. It is not only about design or construction stages but also about facility management of the building. This method improves collaboration process and structures information for a sustainable building. It is also a data house created during the whole process that can be useful for all the stage of the building. All these information stored on the model will benefit operations and maintenance of an asset.

It must be said that the digitalization of design has seen a first evolution from 2D CAD systems, with graphic information, to 3D modeling, also with graphic information only. The contribution of the BIM process can be seen in the fact that it includes graphic and non-graphic information. BIM, as a digital process for the construction industry, offers multiple dimensions:

- 3D modelling | geometrical, graphical information
- 4D time-related info | construction sequencing by means of Gantt charts and timelines
- 5D cost analysis| cost management, construction cost estimating, etc.
- 6D sustainability| environmental, economic and social sustainability impact studies We need to achieve a balance between sustainable environment, economic and social aspects[1] , with an efficient building process.
- 7D life cycle and maintenance | Facility Management: planning and management of maintenance operations throughout the building's lifecycle.

For this paper will focus more on the 6D BIM**,** sustainability, environment and energy efficiency. the sixth-dimension is associated with aspects related to energy efficiency and the sustainable development of a new or already existing building.

For building, the 6 D Dimensions is important to estimate energy consumption at an early stage, so the design can follow with a minor change to reduce this consumption. It also allows for detailed energy simulation and analysis so we can optimize a building energy consumption.

For Arid and semi-Arid countries, this dimension is very useful seeing it can reduce energy uses by changing orientation, opening dimensions, plants walls, natural ecosystem, water storage. These simulations allow an exhaustive analysis in terms of economic, environmental, energetic aspect for a sustainable intervention. Analyzing the energy performance right from the design stage provides the designer the most suitable technical solutions to be adopted to ensure lower energy consumption, greater quality and comfort thus guaranteeing the sustainability of the project.

We can't underestimate the importance of Data that can BIM use during the early stages of design. These Data can be useful for:

- Site context analysis to better understand the site's natural contours, slopes and geographical features.
- Climate considerations such as sun path analysis, prevailing winds and temperature patterns.
- Energy performance analysis by integrating data related to energy consumption patterns and renewable energy availability.

- Environment analyzing impact, with the ability to analyze environmental impact data to minimize resource consumption and mitigating negative effects on the environment.
- BIM has the capability to incorporate various types of data, including topography, climate, socio-economic data, and more which enriches the design process.

For a sustainable building we need to reduce energy uses, CO2 emissions of a building, water consumption and wind circulation to regulate temperature inside the building during all the life cycle. According to the International Energy Agency IEA "*A building's entire lifecycle is estimated to be responsible (directly and indirectly) for around 37% of global energy and process-related CO_2 emissions, which shows the importance of the built environment in addressing climate change".* According to the national Park Services, Arid regions are known for their need of rain in effect they receive, less than 25 centimeters of rain per year. Semi-arid regions receive 25 to 50 centimeters of rain per year. The climate of semi-arid areas is highly variable with droughts.

The first requirements for a building in these locations is to provide a better life style with a reduced use of energy for air conditioning, water with a smart collecting system, using a particular wall thickness and materials that reduce sun conductions.

BIM as a collaborative process, can estimate at an early stage the expected energy use of a building. Minor changes on design, materials used, details or process can help to move toward a sustainable building.

For arid and Semi-Arid Countries this working process seems to be powerful as we can work for a sustainable design by estimating the energy uses, the emissions CO2 and much more before the construction starts. In the table below we will focus on few aspects of the sustainable building and how can the BIM process help to improve sustainability.

	SUSTAINABLE DESIGN	BIM USES - DIMENSIONS
1	Reduce using energy for air conditioning uses	-Digital tools to estimate energy uses and CO2 emissions. -Early estimate the energy consumption of the building.
2	Sustainable materials	-Include materials characteristics on the model (Building envelop) -Materials and components to reduce thickness of insulation. -Energy efficiency insulation and fenestration. -Thickness of the walls and materials used. -Building energy balance: convection, flow, radiation, energy storage.
3	Natural Ventilation	-Simulation using digital tools. -Ventilation used to reduce greenhouse effect. -Aeration to reduce hot temperature.
4	Site sustainability	-Geo-referencing: Use the location of the building to

		work on the sun rise and sun set, shadow, vegetation.

Table 1 : BIM USES TO IMPROVE SUSTAINABILITY

Through the examples displayed in the table, we can see the importance of using data to have a sustainable design. Now that we can see clearly the importance of BIM in design process, will move to part 2 where we will attempt to uncover how the leader of BIM users in the world worked to implement it and make it the best tool nowadays.

2. BIM adoption in the world leader countries.

In today's global environment, and in an effort to achieve environmentally responsible construction, many countries are adopting BIM as a process for building design and management. **The adoption of BIM is increasing worldwide as the construction industry is becoming largely aware of the advantages it offers;** the use of BIM helps to make construction more efficient, cost less and ensure sustainable design and construction. Successful BIM implementation requires the early participation of all project stakeholders.
As any new process of development, the adoption of BIM is different from a country to another, and at different levels**.** The use of latest working process can offer amounts of value to all industries. For that it is important to see how BIM is being adopted in different countries and to know what are the ways that ensure the use. In order to define the statement of BIM implementation in the world, as well as its degree of maturity in the different countries, several studies have been conducted.

Fig 2: *BIM IMPLEMENTATION WORLDWIDE: BETWEEN IMPLEMENTATION AND ADOPTION (MAHMOUDI.O -2021)*

In this sense, *Dr. Bilal SUCCAR (AUSTRALIA) and Dr. Mohamad KASSEM (Northumbria University, UK), Macro BIM adoption: Comparative market analysis*, have conducted an international survey on BIM adoption covering 21 countries based on the *above-mentioned* components. They take into consideration predefined elements in order to measure the degree of maturity and adoption. Among these components we note; objectives, policies, publications, education, standards and deliverables...

Through this survey we note that BIM is used at different levels of maturity in different countries. It is therefore considered that the adoption of BIM is not happening at the same speed in different corners of the world. In fact, each country has started in a different way, in some it is the requirement of the government that takes the lead, in others it is an initiative taken by one or more design office that has made a practice and has generated a standardization.

In April 2022, Yosra TALHA and Zakariae ELJEMLI, drew up an inventory of BIM in the world through 15 countries, in an article published and accessed on HEXABIM. We can note that BIM implementation varies from mandatory to future mandate or encouraged and recommended use as following:

- BIM is mandatory: In some countries, such as **United States** (since 2010), **UK** Since 2016 for the BIM level2, **Netherlands** since 2012 for public projects of more than 7000m², **Denmark** since 2007 for public projects above 5 million kroner and since 2011 for all regional and local institutions.

Finland is the most advanced country in the world as since 2007 the use of BIM is mandatory for all projects over 2 M€, moreover, 90% of architectural firms and 60% of engineering firms regularly use BIM.
Norway is a precursor country in using BIM process since 2010.
However, it would be interesting to mention the implementation process in a country such as the **United Arab Emirates**, where several projects have been built in BIM mode without any governmental obligation. Given the advantages of the process, the state made the BIM process mandatory for towers over 40 floors in 2014.

- BIM is a future mandatory set: In countries such as **Spain**, **Catalonia**. Also, for countries such as **Germany**, draft laws to impose the use of BIM are underway.
- BIM is encouraged and recommended

There are countries like **Sweden** and **France** that have not yet imposed the use of this process. This classification allows us to confirm that BIM is not used with the same ways on the different countries. Through analyzing the case studies of the countries leader on BIM uses, we can say that the adoption of BIM is done differently, depending on the context of the country starting with the legal texts or the practice imposed by the design offices. We can consider somehow that the obligation of the government to use the BIM have an important impact to generalize it. That is why, it is mandatory in several countries for public project.
In Africa, and according to the BIM AFRICA report: "*The level on implementation is expected to progress in the coming years as firmer project to adopt BIM, thereby creating a supportive environment for digital transformation in the industry."*

We can mention here as an example the Zaha Hadid office in Morocco for the work of the Grand Theater of Rabat. In this project the collaboration between the design office and the local collaborating office was done using the BIM process. Occasionally an upgrade of the various stakeholders on the project was necessary. There are multiple levels of BIM implementation:

- Individual firm level BIM is adopted within a single architectural, engineering or construction company.

- Group of Firms: the implementation can be extended to groups of related firms, such as consultants, contractors working together on the same project. This level enhances coordination and reduce conflicts between disciplines.
- Ecosystems (Countries or regions) BIM implementation in a large scale for countries, regions. This level of implementation is more global with a national strategies for BIM adoption. It involves creating standards, guidelines and frameworks.

The goal of BIM is to improve project outcomes and drive efficiency throughout the construction and design process.

> *"The industry is still bedeviled with many challenges impeding widespread adoption. Knowledge-related barriers, lack of government support, client demand and cost are still major bottlenecks in Africa (BIM AFRICA REPORT-2022)*

These facts are also confirmed in the words of Mr. Reda KESSANTI -Senior architect in Zaha Hadid Architects and BIM coordinator-,when he was asked about how well is BIM developed in Algeria and the Morrocco , he explains that these tools are not widespread over there*, "due to the fact that it is not imposed by the Algerian regulations but also by the fact that it is not taught in schools of architecture or engineering schools in the form of a specialized master, through courses and workshops necessary for its learning, however some public and private owners are beginning to be interested. Even if they do not master it completely, they call upon AMO BIM who become the interface of the customer with all the participants."*

The ecosystem and interoperability are foundational principles that support the approach to the Building Information Modeling (BIM) process. They are the Keys in shaping the best BIM implementation and how its benefits are realized across the construction and design industries.

We can put forward here the idea of the important role of the university in raising the challenges of BIM implementation. This leads us to question the training on this work tool. In this sense, education is a locomotive promoting the democratization of the use of BIM but not only. the employability of academics also.

3. The University as a partner on the BIM implementation process

BIM is a powerful process that in one hand can help improve the AEC industry but to do so it needs to be implemented in a collective way. Government support, clients demand, firms, industries, all are important factors leading toward a sustainable construction.

BIM also created new professions such as BIM manager, BIM modeler, BIM coordinator, BIM consultant... All these contributors need to be trained on BIM process through personnel Training.

Thus, through these different observations, we assume that the government and the personnel initiative are not the only tools to implement BIM, the training is an important pillar in this process. For that we aim through this article to focus on the importance of BIM training at university stage.

In this adoption of the BIM process, we note two trends globally: it is either the government that mandates its use for public projects and it is the project stakeholders who align themselves or it is the organization that has the project that imposes this process since it works with it and the other stakeholders are therefore obliged to follow. We think that in both cases training is an important pillar to help and support the BIM implementation.

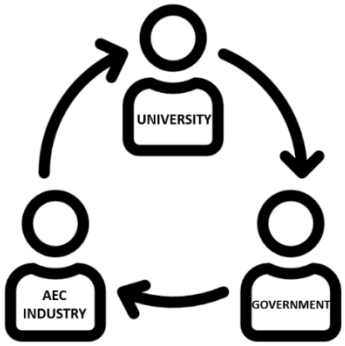

Fig 3: *ILLUSTRATION OF THE THREE PILLARS FOR BIM IMPLEMENTATION*

As lecturer, we are aware of the importance of offering training programs that can help individuals and organizations gain the necessary expertise to effectively implement BIM in their project. But it will be also a valuable initiative to integrate this process into a specialized master's degree at the university level.

This process can be held on the university at an earlier stage. This can give the opportunities to employability but also to have a support for the AEC industry. As said by Pr Kossanti... the conduction of BIM on university will have a major impact to support BIM implementation. The university is an active partner on the BIM implementation and we can't assume an evolution without these pillars.

All the building contributor need to be trained to work within the BIM process, otherwise they are not able to participate. This is a segregation, as we need to invest on softwares, training… for some countries as UK, France, the Government participate on these costs. Investing on software is a strategic decision that can be valuable for a company. BIM software offers specialized tools that will increase productivity and efficiency in project workflows. It also supports real time collaboration among different disciplines, reduce conflicts, prevents errors and improves coordination. But we can't introduce all these or a part of the BIM process on the university level, as a part of the qualification.

Tunisia as an example, is still at early stage of the implementation of the process, just trying the first steps. Government is still not updated to this new process, so the BIM uses are limited to a personal contribution from companies on construction and design and engineering offices, private organizations. Aware of the importance of the BIM process, the university takes the lead in partnership with design offices to start a new master degree at the university of architecture as a reference, and others on engineering are following. This way, through the

university's help to go through this project and draw the attention of the state on the importance of BIM implementation and employability of the new student having license on BIM.

Conclusion :

Despite the challenges of adoption, implementation, and training, BIM can be considered a successful process. The success of BIM is based on several factors, including its ability to enhance project efficiency, reduce errors, and foster collaboration among stakeholders. BIM implementation has gained considerable momentum in recent years. Many countries are developing successful implementation strategies, based on the collaborative triad of government, AEC industry and academic involvement.

The successful implementation of Building Information Modeling (BIM) within a country indeed requires the collaborative efforts of multiple stakeholders, each contributing their expertise and resources. The government, the architecture-engineering-construction (AEC) industry, and universities all play essential roles in the process.

1- The government: Establish regulations, standards, and mandates that require the use of BIM for public infrastructure projects. This ensures consistent adoption and provides a framework for sustainable design practices. It can also can promote open data exchange formats and encourage BIM uses by a tax benefit supporting BIM users.
2- The AEC industry: BIM encourages collaborative design and decision-making, involving architects, engineers, contractors, and other stakeholders from the beginning. It also promotes data sharing and data exchange among disciplines and throughout the project lifecycle.
3- The university life: To introduce BIM for all the architects, engineering students that can take over to ensure the BIM professions. Incorporating BIM into university curricula for architects and engineering exposes students to innovative technology and methodologies used in the construction and design fields. This prepares them for industry demands and increases their employability. Lecturers collaborating on BIM projects can share best practices and experiences, ensuring high-quality teaching and up-to-date knowledge.

The BIM process holds the potential to revolutionize not only architecture and construction but also extend its influence to the urban scale. By incorporating BIM methodologies and technologies into the planning, design, construction, and management of entire urban environments.

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