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Towards Enhancing Building Information Modeling Implementation in the Egyptian AEC Industry

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Abstract

Since the expression ”Building Information Modeling” BIM was initially presented in the Engineering and Construction AEC industry in the most recent decade; it has changed numerous parts of the design, construction, and operation of a building. BIM is a middle ware connector that represents the advancement and utilization of PC.

BIM has various frameworks which have been conducted by the pioneers in the BIM industry to enhance the BIM process. There is a study of the reflection of those frameworks on the Egyptian AEC industry to overcome the threats that prevent Egypt from applying BIM technology more broadly.

In addition, a comparison is conducted between the successful countries which implemented BIM in their projects and managed to enhance their adoption by examining the local challenges and targets. The countries then made strategies and standards to overcome the aforementioned obstacles. Furthermore, successful actions were applied that can match with the Egyptian industrial requirements.

This paper is expected to define the challenges which are facing the Egyptian industry to apply BIM and the potential capabilities of solving those problems. To acquire the vital information to carry on this paper, a questionnaire was created and distributed in the AEC community. The reason for the study was to see how experts consider BIM as a device in the fields of design and construction in general and in the Egyptian industry particularly.

The aim of this paper is to propose a framework through several case studies which are discussed, analyzed and compared. The purpose of the analysis is to explore the importance of using BIM. Additionally, exploring the effect of different parameters on implementing BIM helped significantly during the process. It starts with proposing its framework with evaluating matrix that contains attributes to measure its success, moreover, it serves as a great help to the Egyptian companies that make real business decisions about enhancing BIM implementation through this framework.

Keywords

AEC; Architecture; Engineering; Construction; Industry; Building information modeling; BIM standards; Egyptian firms; BIM frameworks; Return on investment; SWOT analysis; Man hours

1. Introduction

Building information modeling (BIM) is one of the most promising recent developments in the architecture, engineering, and construction (AEC) industry. With BIM technology, an accurate virtual model of a building is digitally constructed. This model, known as a building information model, can be used for planning, design, construction, and operation of the facility. It helps architects, engineers, and constructors visualize what is to be built in a simulated environment to identify any potential design, construction, or operational issues. BIM represents a new paradigm within AEC, one that encourages integration of the roles of all stakeholders on a project.1 AEC firms have understood the advantage of utilizing BIM as a part of project, which was an inspiration for leaving the prior computer aided design framework and use BIM (Hardin & McCool, 2009), as shown in figure 1.

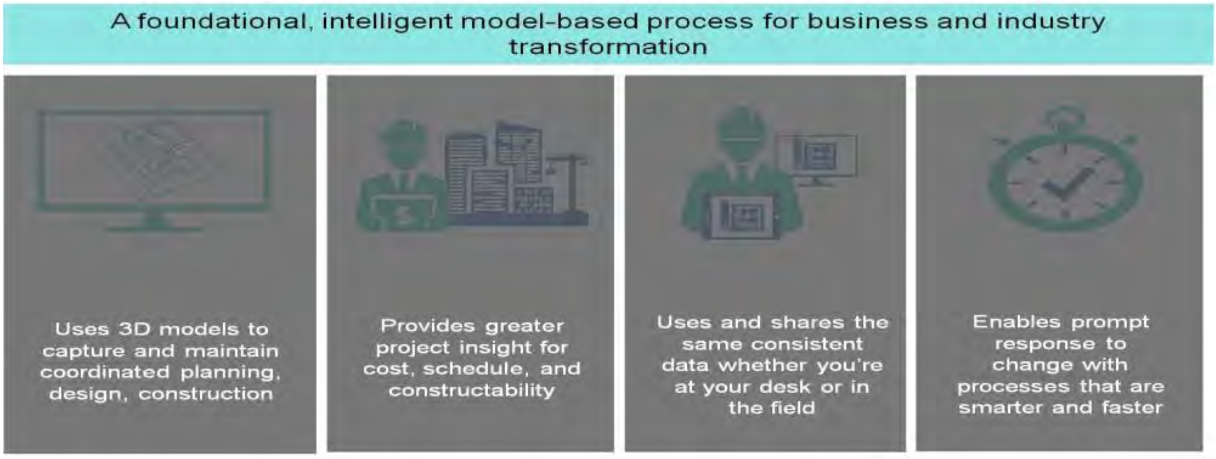

Figure 1. Building Information Modeling Characteristics

2. Building Information Modeling Benefits

The BIM process's mainly benefits are lessening of project risks. Most of the different construction project delivery techniques that have been developed over the past years have more capable of moving risks from one project team member to another, rather than managed much toward lessening that risk (Azhar, Hein & Sketo, 2011). Other related benefits are that BIM is a faster procedure, better design; controls whole-life costs and environmental information, better production quality, and better customer service, proposals are better understood through visualization (Azhar, Hein & Sketo, 2011).

3. Building Information Modeling Risks:

The most legal risks are to determine the ownership of the BIM information and how to maintain it through copyright and other laws (Azhar, Khalfan & Maqsood, 2012). The rest of the BIM risks are categorized into groups as shown in table 1:

Table 1. building information modeling risks categories

Category	Type of risk
Team members	Who will manage the entry of data to the BIM model and be responsible for any mistakes in it. The idea of BIM blurs the level of obligation so much that risk will probably be upgraded (Azhar, Khalfan & Maqsood, 2012). The draftsman, engineers of BIM look to each other with an end goal to figure out who obligation regarding the matter had raised (Azhar, Khalfan & Maqsood, 2012).

Continued on next page

Table 1 continued

Owner	There is no easy answer to the problem of data ownership; it needs answer to every project. Before BIM innovation can be completely used, the dangers of its utilization must be distinguished and dispensed, as well as the expense of its execution must be paid for too (Smith, D. K. & Tardif, 2009)
Contract- ors	In situations where the information is incomplete or is submitted in a variety of scheduling and costing programs, a team member for the most part a general contractor must re-enter and update an expert planning and costing program, that program might be a BIM module or another system that will be incorporated with the 3-D model (Smith, D. K. & Tardif, 2009). Responsibility for the precision and coordination of expense must be contractually addressed.

4. Frameworks for Building Information Modeling

The BIM frame work useful for standardizing the utilization of BIM to help the AEC industry share the project data, and then make projection of that successful lesson learned on the Egyptian AEC industry (Scheuer, Keoleian & Reppe, 2003). Each frame work will be categorized into three sections as follow: Conception, Advantages and Disadvantages. In order to benefits from the strong points in each framework and be able to make use of it in the Egyptian framework, which will be suggested (Scheuer, Keoleian & Reppe, 2003).

4.1. *Succar BIM Framework*

A prototypical framework and an investigative methodology to identify, capture and represent BIM interactions. The framework is composed of three interlocking knowledge nodes and their push-pull interactions (Succar, 2013).

- Framework Conception; this framework consists of three fields (policy node-process node –technology node), as shown in figure 2.1. They have sub nodes and these nodes have two relations, The BIM Policy, process and technology nodes: The first node is the field of interaction generating research frameworks, standards and best practices for minimizing conflict between BIM stakeholders, and the second one is the field of interaction between construction requirements, construction deliverables, organizational structures and operational communications for maintaining BIM, and the third node is the field of interaction between software, hardware and networking systems to generate BIM (Succar, 2013).

- Advantages: The advantage of this framework is that the three nodes not only covering different BIM fields, but also each circle include a specific set of players (Succar, 2009). As an example of BIM Nodes and sub-nodes interact with each other, Designers interact with Fire Authorities and other Regulatory Bodies to insure conformity with respective standards and codes, this is an external interaction between Process and Policy Nodes. Also BIM Nodes and sub-nodes not only interact but they also overlap, Overlapping occurs when players or groups work together to form a joint industry deliverable (Succar, 2009). As an example, Policy and Technology circles overlap when their players work together to generate interoperability standards (IFCs are a striking example). So really the importance of BIM Nodes lies in identifying interactions and overlaps between industry players, as shown in figure 2.

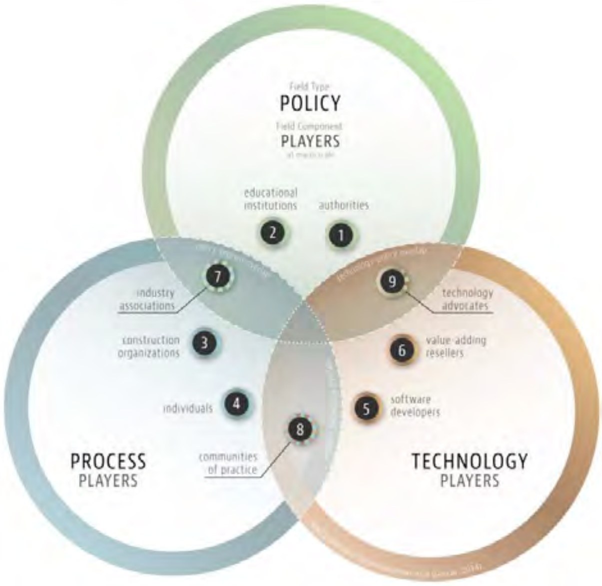

Figure 2. Overlapping between the three nodes, Bilal Succar, Building information modeling framework, 2009

4.2. *BIM Performance Assessment Framework (BIMPA)*

Gu and London framework explains the BIM unit which is a special unit that handles BIM technology implementation. Its characteristics are that it has a specific business function, has a manager, and exists within the organization. It is directly impacted by the BIM technology deployed, and in turn creates BIM value in the form of tangible and intellectual (intangible) capital. BIM value is the value added due to BIM use in an entity (Sher & Williams, 2009). It is conceptualized as the part of the gap between the firm's value and the market value of the same industry that is a result of the BIM implementation. To realize these impacts figure 3 shows the proposed framework attempts to measure the BIM value (Sher & Williams, 2009).

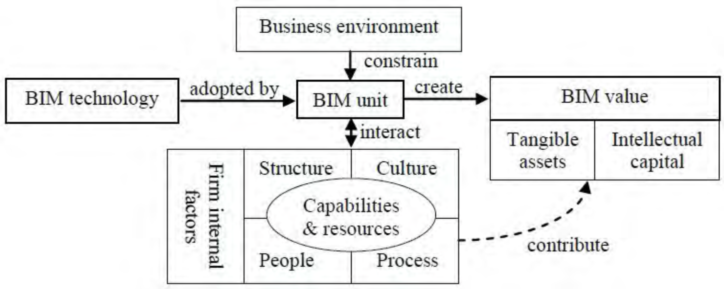

Figure 3. VisualizedBIM implementation at the corporate level, Measuring BIM performance: Fivemetrics,2012

- Framework Conception: The BIM perception model assists top management in the adoption of BIM. The management must evaluate the benefits against the costs and risks involved in implementing the technology (Gu & London, 2010). A cost-benefit analysis (CBA) is used to estimate the value of a BIM investment. The return on investment (ROI) is limited to tangible costs and benefits, whereas the risk & cost-benefit analysis (RCBA) technique is a more comprehensive method because both tangible and intangible costs and benefits are considered, concerning the BIM adoption model it aims to define the Critical Success Factors (CSFs) that decision makers use to decide whether to implement BIM technology, but the BIM performance model aims to and use KPIs for BIM performance measurement (Gu & London, 2010). There are no KPI measures among existing frameworks. Therefore, BIM adopters may choose a single or mixed framework based on their own needs (Gu & London, 2010).

- Advantages: Assists top management in deciding on the adoption of BIM technology through BIM Perception Model, allow cost benefit analysis, define the Critical Success Factors (CSFs) that decision makers use to decide whether to implement BIM technology, efforts to assess and measure BIM performance (Gu & London, 2010).

4.3. *Comparison between different frameworks*

Finally, there is a need for a holistic framework addressing the consolidation of fragmented concepts and to assess BIM impacts on performance in the AEC industry, which proposes a BIM performance assessment framework, which attempts to identify and improve the critical factors that affect construction performance (Succar, 2013).

Table 2. Comparison between different BIM frameworks

	Succar (2009) BIM framework	Jung and Joo (2011)	Gu and London (2010)
Conception	Succar (2009) introduced a BIM framework for the AEC industry that covers the areas of technology (deliver/develop tools, systems), process (who procure design, construct, manage and maintain facilities), and policy (who educate practitioners and conduct research).	They proposed a BIM framework that covers BIM technology, construction business functions, and BIM perspectives.	Analyzed the readiness of the AEC industry with respect to products, processes, and people, and then proposed a collaborative BIM decision framework in an attempt to position BIM adoption in the industry.
Disadvantages	The framework lacks any measure for assessing performance. Despite the efforts to assess BIM performance, the framework still targets industry stakeholders.	It was limited to identifying promising areas and driving factors for BIM in practice (Mom & Hsieh, 2012).	This analysis discussed only the mapping process and not performance measurement, Clear process to manage BIM performance has not been provided (Liu, 2017).
Advantages	BIM Nodes and sub-nodes interact with each other As an example, Designers interact with Builders to generate Facilities; this is an internal interaction. Also Designers interact with Fire Authorities, this is an external interaction between Process and Policy Nodes (Succar, 2013). Overlapping occurs when players or groups work together to form a joint industry or generate a joint industry deliverable.	Variables attempt to be fully independent of each other in order to facilitate further analysis and applications (Jung & Joo, 2011). Figure 4	Have developed BIM guidelines (AGC, 2006), BIM protocols (Ohio DAS, 2010; AIA, 2008), and integrated project delivery methods (AIACC, 2007) to describe the needs, requirements, and obstacles for BIM implementation.

From the previous frameworks, it has been analyzed that each company has to have a framework that measure the BIM performance and facilitate the implementation, so it has been concluded that the framework should include three main parameters which are the stakeholder involvement, the technology issue and the regulation or standards

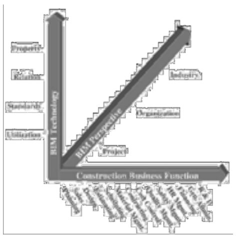

Figure 4.

to make roles for adopting the BIM process, as shown in figure 5. As a result, frameworks can generate a tool to compare the performance of BIM through (KPIs) -which lacks in the previous analyzed frameworks-to be able to evaluate the success of any framework by a list of attributes:

- Efficiency with cost per project/Man hours spent per project: comparing the time spent on project using BIM engineer with the man-hours spent by a drafts man using CAD, to record the effectiveness of actions.

- Speed of Development (Clash Detection): the time spent to detect the clashes is important and needs to be handled in a proper way, in order to reduce additional work and costs and maximize the client satisfaction.

- Measuring the quality of projects: Visualization will improve the coordination and enhance the quality.

- Measuring the skills of employee and the development of knowledge

Weighting should be carried out once data is gathered to measure the performance.

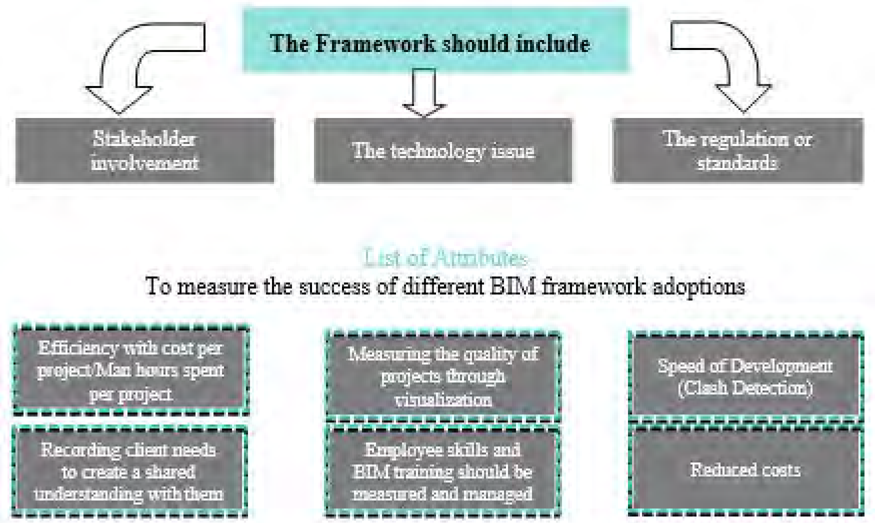

Figure 5. analyses of BIM framework and standards components

5. Analysis of BIM Implementation Case Studies

The selected case studies aim to show that BIM helps in improving the AEC industry, and that BIM can be used as a sustainable tool through energy analysis, also seeks to explore if BIM implementation helps in enhancing the coordination to reduce the wastes factors. The methodology will be through several case studies which will be discussed, analyzed and compared, to explore the importance of using and implementing BIM through fixing the company parameter and measuring the different aspects and challenges. Conclusions were found from large scale projects of a company that has been successfully using BIM practice, also with the help of interviewing professionals in the AEC industry. Three case studies of large scale projects were selected, which have different function to show how BIM affected the industry, the project delivery time, cost and quality.

5.1. *Criteria of the Case Studies Selection Approach*

The case studies had BIM data exchange with more than one other, and the selection was based on:

- Recent projects; to explore the latest state of practical technology implementation.

- International firm that executes projects in Egypt and other countries to make a successful comparison.

- Project types as multifunction projects to cover the different functions of projects that implement BIM.

- Project size; not choosing small or medium projects scale to make it easier, but study and analyze mega projects to maximize the benefits and to cover more problems and coordination benefits.

- Project location: one of the case studies is in Egypt to serve the scope of the paper and the rest are in the Middle East due to the similar position and challenges and they also have Egyptian workers and engineers.

5.2. *Case studies attributes*

There have been some major points that were taken into consideration through selecting the three case studies; (case study 1: Midfield Terminal Building of the Abu Dhabi Airport, case study2: Riyadh Metro Project, case study3: The Nile Corniche Project in Cairo). The points are related to the scope of the paper to manage useful comparative analysis, the point to be studied in each case study will be as shown in figure 6.

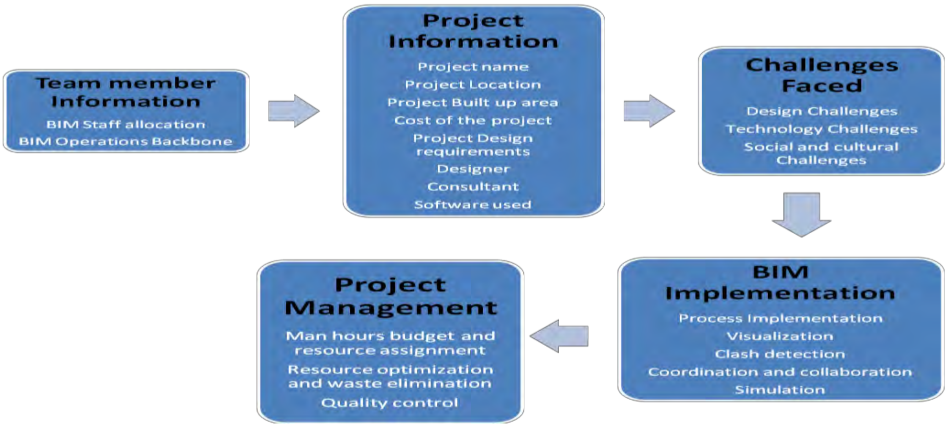

Figure 6. the case study attributes

According to previous data mentioned, the case studies can be analytically compared to find if BIM implementation can enhance the AEC industry for better results. Weights are given based on interviews made with team members in the three projects, and from studying the attributes of the three projects. The weight is 1-5 points where 1 is the worst and 5 is the best weight. NA refers that this point is not applicable.

Final evaluation will be determined as follows:

- full implementation 80-100 % - intermediate implementation 50-80 %

- low implementation 0-50 %

Table 3. Comparison between the previous three case studies

Point of comparison		P1(Abu Dhabi Airport) Figure 7	P2(Riyadh metro) Figure 8	P3(Nile corniche) Figure 9
Plot area	Built Up Area 700.000 m2	178km-long	Built Up Area 197.227 m2	

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Table 3 continued

Average number of architects in the team		40	NA	5
Software used		Bentley	Bentley	Bentley
Attribute 5 (Challenges faced)	Design challenges	2	2	4
	Technical challenges	4	3	1
	Social and cultural challenges	4	3	1
	BIM manager	5	5	5
	Visualization	5	5	3
Attribute 6 (BIM im leme tatio)	Coordination and collaboration	4	3	2
	Simulation	5	2	4
	BIM standards	5 Client standards ADAC	5 CAD standards(AIA)	5 VICON standards (consultant)
	Time saved (through implementing BIM)	5	4	2 Social Challenges affected the time
	Cost saved (through implementing BIM)	5	NA	NA
Attribute 7 (roject manageme t)	BIM client demand	5	5	5
	Planned delivery date with scheduled	5	5	1 some political reasons
	IPD	5	4	1
	LOD (100-200-..-500)	5 LOD 500	5 LOD 500	3 LOD 350
Attribute 8 (BEM)	Sustainability	4	1	1
Evaluation		66 / 75	51 / 75	38 / 75
BIM implementation %(full-intermediate-none)		88% Consider as full implementation	68% Intermediate implementation	51% Between low and intermediate implementation

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Table 6 continued

Evaluation		66 / 75	51 / 75	38 / 75
BIM implementation major benefit		For construction and FM	Coordination between 6 lines	For construction coordination and MEP

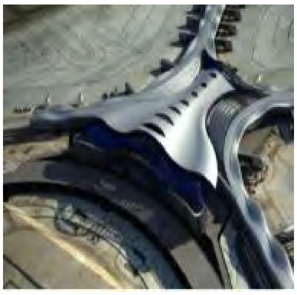

Figure 7.

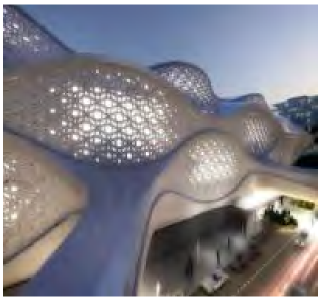

Figure 8.

Figure 9.

Findings from the final evaluation as shown in table 3 which are generated by the researcher:

- Project P1 (88%) had fully implemented BIM in a successful practice; BIM was used in a unique and creative way to improve the current process practice.

- Project P2 (68%) —Project P3 (51%)

This table is a summary of the major learning points of the three case studies, which illustrate:

In the first case study when the full implementation of BIM process occurred there were benefits in all areas (Time-Cost-Coordination-Visualization-Client satisfaction) and those benefits were the highest between the three projects. In the second one the BIM implementation was less than the first project, in spite of applying standards but the existence of social challenges affected the process, the benefits were less than the first project. In the third case study the BIM implementation was the least between the three projects and this is due to the major challenges in many aspects such as social and political changes between Egypt and Qatar.

So it is not the matter of applying BIM or not that would enhance the AEC industry, and we cannot predict that even if we facilitate all the points that could enhance the BIM process such as IT departments, BIM managers, standards the BIM will be a solution for all the AEC projects. This is because every project has its unique challenges and aspects.

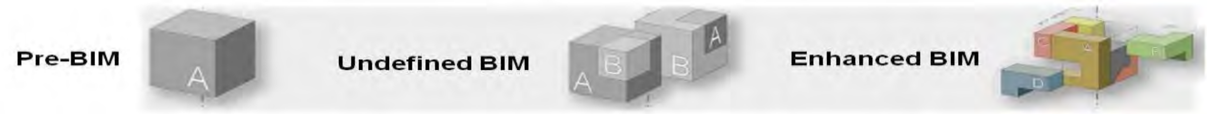

Figure 10. the revolutionary phases of model

6. The Proposed Framework

The main conclusion of the paper is summarized in figure 11, showing the cycle relationship between government, process, technology, business, execution and BIM performance measurements represented in terms of **inputs and outputs** resulting in:

- Establishing metrics to evaluate the success of the proposed BIM framework. - Testing the metrics with the attributes of the case studies, specifically projects that are Non-BIM versus BIM in the same organization.

- Providing limitation of the framework from the data.

- Validating the resultant framework model established to evaluate the net benefit or lack thereof from BIM.

6.1. *Generation process of the framework*

The procedure of generating the framework has been illustrated, as shown in figure 7, and mentioned below in detail:

Figure 11. generationprocess of the framework

- First: the frame work benefits from the literature reviews: From the different analyzed frameworks that were developed by successful pioneers in the BIM field which have advantages that have been used such as introducing a BIM framework for the AEC industry that covers the areas of technology, process, and policy, and disadvantages that we tried to avoid and search for solutions to them such as lacking any measure for assessing performance by designing a performance node. This means that we need to design performance node. Also from the world wide BIM standards which achieved success and gained reputation in applying BIM which helped in the framework to learn how those countries succeeded in making development of BIM to benefit from them in the Egyptian firms. This means that we need to design policy node represented in government.

- Second: the frame work benefits from the interviews: From the findings after the interviews the result is that we should provide trainings/education for BIM technology in companies and providing education communities to advise the client about the importance and benefits of using BIM for him the project. This means that we need to design process node.

- Third: the frame work benefits from the case study: The framework benefits from the case study by facing the practical advantages such as saving cost/time and maximizing coordination through applying standards ,the development of IT department, increasing the awareness of stakeholders, existence of BIM specialist, also by avoiding the different challenges that could face any company/country such as the political and social challenges which could affect enhancing the BIM implementation, so the experience could be generalized to the whole Egyptian AEC industry. This means that we need to design Business node.

6.2. *Elements of the framework*

1. The Nodes: represent the phases or the process of the framework to maintain the BIM implementation; also it varies in the size when it comes to government and performance node. The government node is at the beginning of the process with the largest size, because without its role and power the whole framework will not exist in a proper way. Concerning the performance node it is the end of the framework to monitor the performance and enhance it as shown in figure 8, It also plays a huge role because it gives repetitive feedback. The nodes will be discussed as follows:

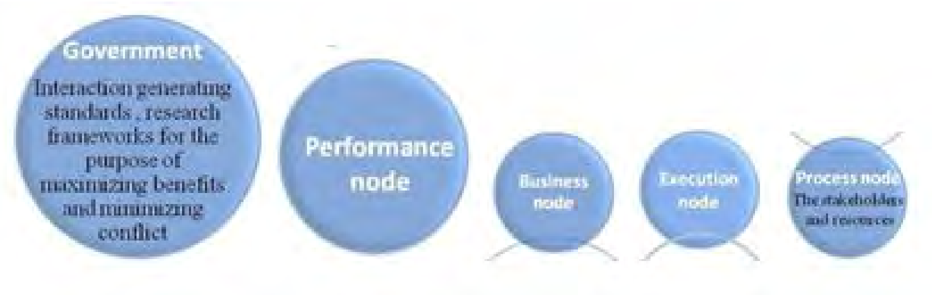

Figure 12. the three different sizes ofthe nodes that represent the framework

- Government node: Indicates to the policy node and it is the first and biggest node because from this node the enhancement process could begin, it includes standards and universities that could educate the students and conduct researches. The government could develop a new ministry to be specialized in implementing, monitoring and enhancing the BIM process which will reflect on the hall AEC industry that represent huge part of the Egyptian economy, this ministry should make plan with certain duration and the Role/Characteristics of the ministry should be establishing a programme for the collection and analysis of BIM data to capture lessons and share best practice, Committing to an Egyptian BIM organization as a vehicle to allow it to achieve fully integrated BIM, also it should seek global partners in developing International BIM standards to enable software to work together more effectively, and it should invest in future cities to create a demonstrator that launched in certain date.

- Process node: Represented in Clients and project managers - who make decisions concerning the implementation of BIM, and could affect the team members of the project, when the awareness of the stakeholders increase the output will be the demand of the client for such a service.

- Business node: If the stakeholders became satisfied with the process, it will encourage the companies which are represented in the business node to Change the perception of BIM, which will make the firms gain more than already receive, this node represented in senior technical officers, managers and executives of an organization.

- Technology node: This node represents the software, hardware, networks, specialized equipment and BIM database. To identify technical requirements of BIM and the levels of interoperability

- Execution node: This is an ongoing node and there might be future enhancement and refinements after the execution of the framework.

- Performance node: In order to evaluate skills, performance and capabilities after the monitoring process to maximize the benefits and avoid the problems occurring after completing the loop of the framework. 2. Inputs and outputs: each input affects the node which leads to outputs that will be inputs for the next node and so on in a closed loop, as shown in figure 13.

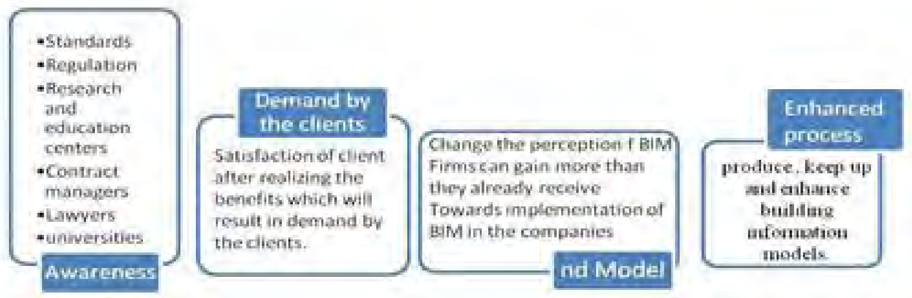

Figure 13. Inputs and outputs of the framework

3. Arrows: the measurements and lesson learned are represented in a closed loop from the performance node back to the government to assess and evaluate the process and benefit from the successful and in successful lessons, as shown in figure 14.

Figure 14. The arrow represents the loop from the performance node back again to the government

6.3. Evaluation of BIM framework implementation by the user group

Evaluation matrix of BIM framework is necessary because without such metrics, teams and organizations are unable to consistently measure their own successes and/or failures. Performance metrics enable teams and companies to assess their own competencies and to benchmark their progress against that of other practitioners. Accordingly, each node has its measurable attributes with certain weight, which are 1-5 points where 1 is the worst and 5 is the best weight as shown in table 4, and the Final evaluation will be determined after calculating the total weight of the BIM implementation of the organization to be as follows:

- full implementation 80-100 % - intermediate implementation 50-80 %

- low implementation 0-50 %

Table 7. Evaluation matrix of BIM framework implementation by the user group

Nodes	Measurements Attributes	Scale				
Government	is the ministry achieving their role?	1	2	3	4	5
	Standardizing information and measurement process					
Process node	Is the client involved in the process?					
	Availability of BIM skills and trainings for the employee					
Business node	Compare the man-hours spent using BIM process with using a traditional way					

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Table 7 continued

Nodes	Measurements Attributes	Scale				
	Speed of Development (Clash Detection)					
	Better quality through visualization					
	Better product through coordination (simulation)					
	The cost reduction					
	The time saved					
Technology node	Availability of strong IT department					
	Is there enough cost to apply BIM process?					
Execution node	Existence of ongoing enhancement					
	Availability of quality measurements					
Total						
Performance node	Full BIM implementation (80%-100%)					
	Intermediate BIM implementation (50-80%)					
	Low BIM implementation (0%-50%)					

6.4. Limitation of the framework

This framework could be applied only in certain conditions, because there is no successful frame work that could be applied for all the companies/countries, every company has its conditions and this frame work could work only in the organization that has those criteria**:**

- High income company, because low income company would not be able to afford the cost of BIM.

- Companies that execute large projects, because using BIM application in small projects will not achieve the targeted returns which have to be on the same level and cost of BIM. -

Companies that will apply BIM framework should be under the supervision of the government, even if it is a private company it has to be monitored in order to maintain the BIM process in its best way and not to become the traditional way that exists now which represents the process as a tool or only Revit software.

- Every company should have its own hierarchy and a BIM specialist/ department.

- There are also many limitations but it will be more obvious with the practical implementation and testing the framework, because it is not the matter of applying BIM or not to enhance the AEC industry, and we couldn't tell that if we facilitate all the points that could enhance the BIM process such as IT departments, BIM managers, Standards and Raise the knowledge the BIM will be a solution for all the AEC projects, because every project has its challenges and aspects.

7. Conclusion Remarks

From the frameworks analyzed previously, and from the three case studies which have been studied, analyzed and compared, the following key findings were observed. Regarding BIM implementation in Egypt, there are reasons that limit the enhancement of BIM application in Egypt, which are the fear and resistance of change, lack of training on BIM software, lack of standards that regulate the BIM implementation in Egypt, also the contract issue, lack of knowledge about BIM in the Egyptian firms. Also, working hour's appropriation among design stages relies upon the used design too. In the traditional workflow, most of the time is consumed while making the development documents. But when BIM is used, most of the working hours are required amid schematic and developing stage wiping out wastes in later construction, maintenance stages and through the entire life cycle. Regarding the stakeholders: The main director for using the BIM process in the Egyptian firms is the client. This accordingly will increase the percentage of BIM implementation in case of developing the awareness of the stakeholders. Also the clients become satisfied from the BIM process, because of the complete insight to the project in the whole phases. It enhances the visualization, time control, cost estimating.

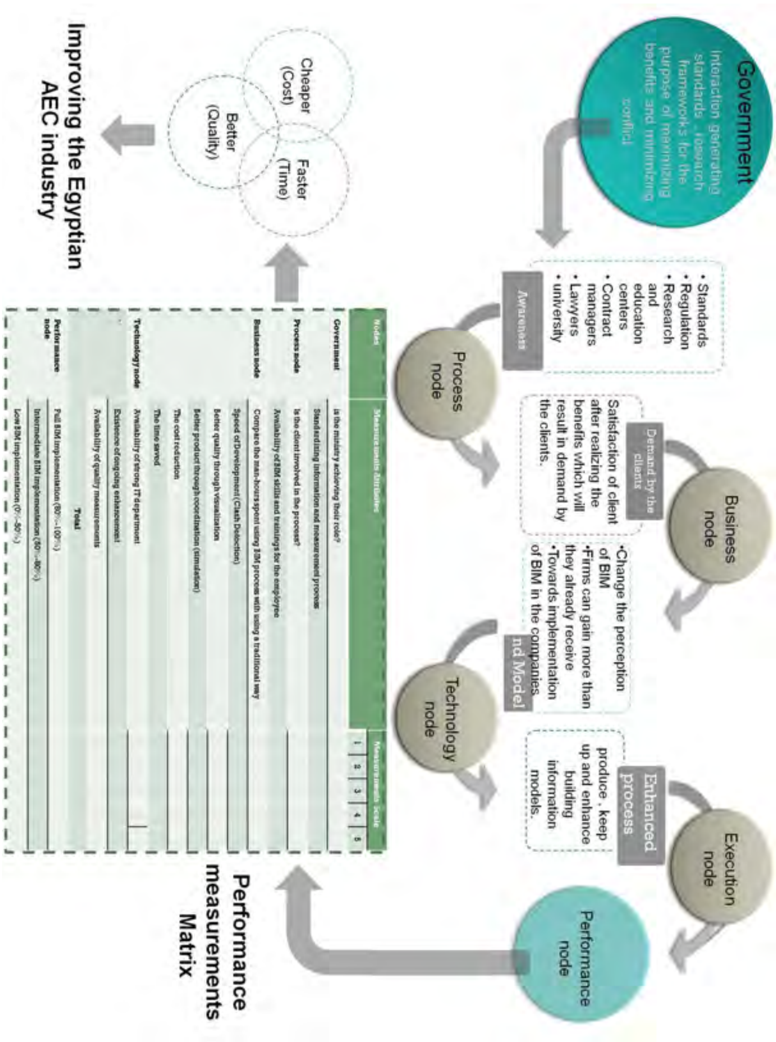

Figure 15. the proposed BIM framework for enhancing theimplementation of BIM in Egypt, generated by the researcher

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