

Barriers to the Adoption of Building Information Modeling in the Jordanian Building Industry

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Abstract

In the last decade, construction industry has witnessed a huge transformation in term of the use of digital technologies, and particularly Building Information Modeling (BIM). BIM is a revolutionary digital technology and process that is reshaping the Architecture, Engineering and Construction (AEC) industry. Though, internationally, BIM has gained a great reputation for boosting productivity in AEC industry, but it holds undeveloped possibilities for providing and supporting AEC industry in Jordan. This study aims at exploring the adoption of BIM within the Jordanian construction industry. To achieve this objective, the research commenced by carrying out an intensive literature reviews on the implementation of BIM world-wide and in Middle East, which was utilized to identify the benefits and challenges of BIM in construction industry. An exploratory study was then conducted using an on-line survey to identify the current level of BIM experience, and to define the perceived benefits and challenges facing BIM implementation. Findings reveal that the adoption of BIM in Jordan is still in a very primitive phase and it faces numbers of critical barriers such as, but not limited to, the absence of government incentives, the lack of BIM standards, lack of BIM awareness, lack of BIM need, cost and resistance to change. Similarly, the study identified the main perceived potential benefits of BIM that were: “clash detection”, “minimizing conflicts and changes” and “reducing rework”. This research represents a first step towards understanding the current situation of BIM implementation in Jordan. It can help AEC practitioners in Jordan recognize potential areas in which BIM can be useful in AEC practice. However, it provides a benchmark for future studies that should tackle several other avenues further.

Keywords

BIM, Construction Industry, Jordan

1. Introduction

Although the construction industry is considered one of the biggest industries worldwide [1], it is still lagging behind other industries in terms of productivity, efficiency, quality and sustainability. For industries other than construction, improved productivity could be attributed to advances in and increased usage of information technologies, increased competition due to globalization, and changes in workplace practices and organizational structures. Since the traditional industry model has no significant changes accompanying the introduction of new digital tools and technologies; therefore, it still exhibits a low maturity in the use of IT that has negative reflection on its productivity level. Many studies [2] [3] were conducted to address this gap between building industry and IT, one of the most important studies was conducted in 2004 by the National Research Council (NRC) that focused on providing strategy for advancing the competitiveness, efficiency and productivity of the U.S. construction industry. Findings of this study identified that interoperable technology application, also called Building Information Modeling (BIM) is not just the key solution, but also the most promising in terms of improving the quality, timeliness, cost-effectiveness and sustainability of construction projects.

BIM is an improved process and a tool that involves applying and maintaining an integrated digital representation of different information across various phases of a building construction project [1] [4] [5] [6]. This technology, covering the entire life cycle of the building can create, coordinate, document, manage/operate and update information about a particular facility. This is a major change in the process of transforming the construction industry worldwide [7]. Accordingly, the implementation of BIM supports the concept of Integrated Project Delivery (IPD) which is a novel project delivery approach to integrate people, systems, business structures and practices into a collaborative process to reduce waste (of time, sources, money) and optimize efficiency through all phases of the project life cycle. Many governments have set implementations strategies for the use of BIM [8] on construction projects that has resulted in the wide spread of the adoption of BIM for instance, the UK [9], USA [10] and Australia [11]. Although, BIM has been on the global construction industry market for a number of years, BIM related technologies are just emerging in Jordan. Yet, there is no study that investigated the current situation of BIM adoption within the construction industry in Jordan. This study investigates the current Jordanian construction industry practices and uses of BIM:

- Assess the level of BIM adoption;
- Identify the benefits and challenges of BIM adoption; and

It is expected that this study is necessary to help practitioners in the construction industry to understand the value of BIM for their organizations and projects.

2. BIM Global Adoption

Building Information Modeling (BIM) is not a new concept; early researches

were conducted on BIM since 1970s. Chuck Eastman wrote on “The use of computers instead of drawings in building design” in 1970. He considered drawings as: “the principal medium for design problem-solving, coordination and for communication” [12]. Since then, series of researches were conducted on the use of ICTs in design and construction management. In 1984, “Standards for the Exchange of Product Model Data” (ISO STEP) and ArchiCAD were introduced as first BIM software for Mac computers. Next, in 1996, the “International Alliance for Interoperability” (IAI), now building SMART, developed the old concept of Building Product Modeling into a new name which is: Building Information Modeling. In 2006, the general services administration (GSA) in US has included a spatial programme of BIM as part of the minimum requirements for submissions to the Office of Chief Architect for final concept approvals. Thus, the country has become a mature BIM market and led its best practice. Resulting BIM adoption in North America rise steeply from 28% to 71% between 2007 and 2012, and the UK and other regions are poised for similar dramatic expansions. In 2010 UK Government announced BIM requirements, and from 2016 onwards, the government of UK mandated the use of BIM in public sector projects. Currently, United Kingdom is a world leader in BIM adoption speed [13].

Although BIM is rapidly expanding around the globe, there is significant difference between construction companies’ experience with the business benefits from BIM in various regions. Further researches in many developed countries such as Germany, France, Brazil, Austria, Finland, Denmark, Norway and Sweden revealed that BIM is gaining wide industry awareness and adoption. A little over one third of the industry in Western Europe (36%) has adopted BIM. BIM is becoming established with contractors in other regions such as Japan, South Korea and Austria/New Zealand represent the next tier of maturity, with a three to five experience tier. This shows how rapidly BIM is advancing. In East Asia, for example South Korea, contractors show a 65% BIM adoption rate in 2012. In south Asia, Singapore has been promoting BIM since 1997; and in 2011 the country issued its nationwide BIM implementation roadmap so that BIM started to be used for various aspects in construction such as building plan approvals and fire safety certifications. From 2015 onwards, the government mandated the use of BIM in public sector projects for new building projects over 5000 m². In China, the government sat a five year plan (2011-2015) to formulate a BIM framework. In Hong Kong, BIM implementation is moving rapidly [14]. This is because clients have started to realize various BIM benefits such as the ability to generate various design solutions and to check designs integration that would minimize errors and maximize productivity. BIM implementation in Africa varies from country to another; for example, meanwhile the level of BIM awareness is high in Nigeria, it is facing huge challenges in South Africa [15]. Looking at the current global status of BIM, it can be argued that BIM adoption and implementation varies from developed to developing countries due to the lack of clear practical strategies to adopt it. Although in Middle East region, BIM implemen-

tation has increased in the past 5 years, but exceptions who mandated it. Several studies suggested that BIM adoption in some countries, like Jordan and Lebanon, in Middle East is still lagging behind the developed countries such as US and UK Emirate [16] [17]. Otherwise some other countries BIM have witnessed a rapid increase in implementation such as UAE, Egypt and Qatar. In 2014, Dubai was the first public authority in Middle East to mandate the use of BIM for most large-scale projects in the Emirate [1] [18] [19] [20].

3. Research Methodology and Strategy

This study aims at investigating the current situation of BIM within the construction industry in Jordan. To achieve this objective, the research commenced by carrying out an intensive literature reviews on the implementation of BIM in Middle East and worldwide. An exploratory study was then conducted using a structured, on-line survey that was designed based on the literature review to identify the current level of BIM experience, and to define the perceived value, benefits and challenges facing BIM implementation. The questionnaire was designed to be simple and direct yet specific to capture the current state of practice in Jordan as to the use and implementation of BIM.

4. Results and Analysis

The sample for this study consists of architects, engineers (civil and MEP) and contractors operating in Jordanian AEC construction industry. Results of questionnaire are presented in the next subsections.

4.1. Respondents' Profiles

This survey was conducted through an internet survey of industry professionals between November 27, 2016 and respondents January 21, 2017. The survey had 180 complete responses. The "total" category displayed throughout the study includes 77 architects (43%), 31 engineers (17%), 36 contractors (20%) and 36 other industry respondents (20%)—including owners, planners, building product manufacturers, government agencies, various integrated firms and consultants. So the distribution of the respondents in the survey was not a normal distribution and it shows that the architects have the most interest among others to participate in surveys and knowledge about BIM.

Table 1 shows distribution among respondents according to their age, around 39% of the respondents were within the category of 31 years to 40 years followed by respondents of 41 to 50 years and the least category was respondents older than 50 years (15%). However, the respondents' education level was varied from 82.2% for Bachelor's Degree holders, followed by 14.5% for Master's degree holders, and only 3% of PhD degree holders.

Respondents' profiles were classified according to the size of the respondents' companies firm. 69% of the companies were medium companies (with 50 to 199 employees) followed by large companies (21%) of 200 - 999 employees, the least

Table 1. Respondents' profile.

RESPONDENT INFORMATION	CATEGORIES	FREQUENCY	PERCENTAGE
Age	25 - 30	27	15%
	31 - 40	70	39%
	41 - 50	52	29%
	>50	31	17%
Educational level	Bachelor's Degree	148	82.2%
	Master's degree	26	14.5%
	PhD degree	6	3.3%
Firm Sizes by Number of Employees	1 - 49	13	7%
	50 - 199	113	63%
	200 - 999	38	21%
	>1000	16	9%
Specialist	Architect	77	43%
	Engineer	31	17%
	Contractor	36	20%
	Other	36	20%
Experience in Construction Industry	1 - 10 Year	79	44%
	11 - 20 Year	56	31%
	21 - 30 Year	40	22%
	>30 Year	5	3%
Total no. of valid questionnaire = 180			

Source: Authors, 2017.

respondents were found in two categories: the very large companies with more than 1000 employees (1%) and the small companies with fewer than 50 employees (9%).

In terms of years of experience in the AEC construction industry, respondents were having varied experiences. About 41% of respondents had experience between 2 to 5 years followed by 27% of respondents had more than 15 years' experience, 29% respondents have from 5 to 10 years working in this industry. Only 3% had less than 2-year experience in the industry, while 87% had over 5 years of experience. 9% of respondents had between 10 to 15 years' experience.

4.2. Respondents' Experience of BIM

As shown in **Table 2**, the current experience of BIM is still low as the majority of respondents had 2 to 5 years' experience working with BIM (45%). These were followed by respondents had 5 to 10 years' experience working with BIM (33%). And the lowest response rate was from respondents had more than 15 years' experience (3%). Obviously, implementation of BIM in Jordan is still in a very early stage.

Table 2. Respondents' experience working with BIM.

RESPONDENT INFORMATION	CATEGORIES	FREQUENCY	PERCENTAGE
Years of respondents' experience working with BIM	>15	5	3%
		13	7%
	10 < years < 15	59	33%
	2 < years < 5	81	45%
	<2 years	22	12%
Number of BIM projects that respondents have worked on	80% < time < 100%	10	5.6%
	60% < time < 80%	19	10.3%
	40% < time < 60%	24	13.4%
	20% < time < 40%	49	27.2%
	<20%	78	43.5%
Respondents training with BIM	University courses	5	3%
	In-house training	22	12%
	Industry Led training	36	20%
	None/Self-taught	117	65%
Most common BIM tool used by respondents	Revit	162	90%
	Navisworks	90	50%
	Bentley	99	55%
	Sketchup	126	70%
	ArchiCAD	108	60%
	Tekla Structure	63	35%
	Other	27	15%
The most common use of BIM in the project life cycle in Jordan	Design Phase	27	70%
	Construction & Documentation	36	20%
	Facility Management	13	7%
	Other	5	3%
project delivery method	Design-Bid-Build	113	63%
	Design-Build	31	15.4%
	GC/CM	9	5.1%
	Other	39	16.5%

Source: researchers, 2017.

Respondents' BIM experience level was investigated through asking them about the consumed time on tasks that require hands-on BIM experience. About 43.5% of respondents spent less than 20% of their time on BIM tasks. And only 5.6% of respondents spent from 80% to 100% of their time on BIM tasks. This finding was in line with what found of majority numbers of respondents worked

on few projects from 2 to 5. Interestingly, when different firm types are analyzed, general contractors have the least hands-on experience; 73% of respondents spent less than 20% of their time using BIM, followed by 42% of construction managers. Again, architects have more hands-on experience with BIM than the other disciplines.

Next, respondents were asked to determine the way they taught BIM. It has been found that 65% of the respondents were self-taught on BIM, where the majority could know the tools of BIM but not the process. "Industry training" was followed with 36 respondents (20%) indicated that their organizations and companies had provided training for employees to learn the process and its tools followed by "in-house training" with 12% and it was only with 3% of respondents who got their training from colleges and universities. Usually university training courses on BIM is very basic and it's more on the use of the software rather than the process of BIM. This finding confirmed Rita Awwad's (2013) findings in her research on BIM in Middle East, where she found that universities in Middle East include BIM within their programs' curricula as a course at the graduate level or as a part of a scheduling course at the undergraduate level. None of these colleges have BIM as a requirement for engineering students. In Jordan, its only three universities out of 19 surveyed universities offer BIM as an elective course to their students. These findings show further the lack of BIM awareness in the market.

Results presented in **Table 2** shows different BIM tools available widely in the Jordanian construction industry market. Autodesk software was the most common tools used in BIM, such as: Revit, sketchup, Archicad and Bentley with 90%, 70%, 60% and 55% respectively. Navisworks was in the second place with 90 responses (50%), where it was mainly used for construction schedule simulation. However, 35% and 15% of the respondents selected Tekla and other software respectively.

This corresponds to what most of the respondents indicated about the most common use of BIM in the project life cycle. As majority of respondents (70%) stated that BIM was used in the design different phases for design-related functions such as building design, visualization, programming and massing studies. Otherwise, 20% of the respondents used BIM in the construction documentation followed by facility management of 7%. Only 5 respondents (3%) indicated that BIM was utilized in other functions. However, data showed that the design phase seems to be the most important phase and this can be explained due to the general understanding, on the part of our participants, of "BIM as a modeling tool that enable visualization of buildings.

Respondents were also asked on the project delivery method that was used in their projects. It has been found that Design-Bid-Build was the most common used delivery method for construction projects in Jordan with 113 respondents (63%) followed by Design-Build with 28 responses (15.40%). 19 respondents indicated other methods such as Cost-Plus, Design-Build-Operate, etc.

5. Current Status of BIM Adoption

5.1. Benefits of BIM Adoption in Jordan

The advantages provided by the new technology are the key to its full implementation. Another objective of the survey was to determine the different views of respondents about the major benefits realized through implementing BIM in their projects. **Table 3** shows that respondents believed that BIM provides multiple benefits. Furthermore, the main perceived benefits of BIM implementation were almost consistent across most of respondents as rated in **Table 3**.

95% of respondents agreed on BIM ability to reduce the rework and design errors and changes during construction processes to a large extent; thus improve productivity. Moreover, 85% of respondents believed that BIM improves visualization, which resulted in enhancing design scheme options. Consequently, this results in time reduction, and minimizes the cost and maximizes productivity. Similarly, 85% of respondents believed that BIM enhance collaboration and communication between the different project entities facilitating early engagement with the relevant disciplines. Moreover, they realized that BIM can also help with localized engineering solutions such as design review, project documentation, clash analysis, shadow analysis, cost analysis, etc. Arguably, BIM offers support to designers in enabling designs to be checked automatically against constraints. To summarize, most of the respondents were in agreement that BIM implementation is very important and beneficial, particularly in term of productivity. Accordingly, the productivity related benefits of using BIM can be identified as follows:

Table 3. Benefits of BIM adoption in AEC construction in Jordan.

Advantages	Frequency	PERCENTAGE
Reduce Rework During Construction	171	95%
Maximizing productivity	162	90%
Reduce conflict/changes	158	88%
Clash detection	158	88%
Enhance collaboration & communication	153	85%
Improves visualization	153	85%
Improve project documentation	153	85%
Enhance design review	144	80%
Faster & more effective method	153	85%
Improve Quality	151	84%
Reduced Construction Time	126	70%
Reduce Contingencies	117	65%
Reduced Construction Cost	126	70%

Source: researchers, 2017.

- Reduced rework is the highest rated benefit among respondents. 80% of experts in using BIM stated that this aspect rates a high value.
- Clash detection and minimizing conflicts and changes during construction are among the top rated ways engineers said BIM adds value to a project and owners believe BIM saves time and money.

5.2. Barriers and Obstacles of Implementing BIM in Jordan

The implementation of every new technology faces some challenges before fully applied. Another scope of this study was to investigate barriers of implementing BIM within AEC construction projects in Jordan. Respondents identified several barriers ranging from technical issues to the more human factors, which are critical for BIM adoption in Jordan as shown in **Table 4**.

Table 4 shows four main obstacles that have the most influence on BIM implementation in Jordan, which were:

- The absence of government’s support of any incentives or from mandating BIM implementation at least on public construction projects which scored 95% along with the absence of “BIM industry standards and codes”,
- Lack of awareness about BIM: 90% of respondents are still not aware of BIM benefits and potentials; accordingly, they don’t know where to start”,
- Lack of demand for BIM from clients or others firms, and
- Another two inter-related issues stated by respondents was “resistance of change” and “Lack of a BIM specialist in Jordan” that scored 88% and 85% respectively.

Although the Jordanian government is in the process of enforcing BIM for certain public projects; yet, owners of smaller businesses usually don’t have such demands—and the smaller they are, the more likely to resist technological changes. Almost 75% of respondents indicated that adoption of BIM is too expensive and regarded it as a low return-on investment. It can’t be denied that the move towards implementing BIM requires radical changes in the workflow, practices and procedures in order to take the advantages of its implementation.

Table 4. Key challenges faced BIM adoption in AEC construction in Jordan.

Challenges	Percentage
Lack of support and incentives from construction policy makers: standards and codes are not available	95%
Lack of awareness about BIM	90%
No client demand	88%
Resistance of change	88%
Lack of a BIM specialist in Jordan	85%
Necessary training is not available	85%
Cost (software, hardware upgrade, training, and time)	80%
BIM requires radical changes in our workflow, practices and procedures	65%

Source: researchers, 2017.

6. Conclusions

Building Information Modeling (BIM) is the use of multi-Faceted computer software data model to document a building design, to simulate the construction and to operate a new facility. It can be stated that the current state of BIM implementation in Jordan is still lagging behind. Only large AEC organizations (5%) have prompted a serious move towards BIM in certain capacities, whilst the 95% of organizations are not using BIM in any capacity.

The study identified key challenges that prevent the adoption of BIM in Jordan, such as: “The absence of government’s support” this was followed by “Lack of awareness”, “Lack of demand for BIM”, “Resistance of change” and finally, “The cost of implementing BIM”. Similarly, the study identified the main perceived potential benefits of BIM that were: “Clash detection”, “minimizing conflicts and changes” and “reducing rework”.

Hence it can be inferred that Jordanian government should take a serious step towards drawing up a roadmap and setting local standards and codes for BIM at both the organizational and procedural level.

This research represents a first step towards understanding the current situation of BIM implementation in Jordan. Yet, it provides a benchmark for future studies that should tackle several other avenues further.

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