Obstacles to the use of BIM technology in the construction sector in Kuwait

Mohsen Saud Al-ghurair

Abstract— Previous studies shows that BIM technology makes a huge exchange in construction sector in all stages starting from planning, design, analysis, coordination, construction, operating, data management and maintenance, the most important advantages for the technology was the coordination between project stakeholders, error detection, choosing material before work commencement and real time cost updating. A Questionnaire was prepared consisting of three topics to measure BIM technology awareness level in construction industry and to define importance and priority of applying this technology and to evaluate the barriers of BIM in Kuwait state.

The study results show lack of BIM technology awareness in Kuwait construction industry in general, while there was a necessary need for applying the technology in simulation, planning, coordination between project stakeholders and controlling project cost. On the other side, the study shows that BIM applying barriers in Kuwait were lack of awareness of the technology and absence of committed implementing regulations related to technology. The study recommendations confirmed the importance of training and rehabilitation of workers in construction industry and incorporate BIM technology into curriculum of technical academic institutions and activation of engineering society and concerned civil institutions role to spread BIM technology awareness, Also providing the governmental support by issuing regulations for implementing BIM in major and special projects, thereafter starting to implement the gradual transition to BIM technology in other projects and prepare regulating specifications, codes and contracts to apply the technology in construction industry.

Index Terms—BIM, building information, construction industry, importance, management, modeling, technology.

1 Introduction

The project stakeholders involved in the construction industry face many challenges in completing projects within the specified cost and in the planned time. In addition, they face many problems concerning coordination between different disciplines in the construction industry, Also, there is a waste of materials due to the nature of the multiplicity of activities of the construction industry.

Building information modeling (BIM) emerged as a result of the urgent need to reduce the cost of projects, control the time of implementation of the project, raise efficiency and productivity and solve the obstacles to the implementation of projects. In addition, this technology enables high coordination between project stakeholders. In the design phase, the architectural, construction, mechanical, electrical and health disciplines work on one model. In the implementation phase, BIM technology enables effective follow-up, schedule and coordination between project stakeholders of the project. Also, it become easy to make adjustments to the project and showing its effects on the cost [1].

Building information modeling technology (BIM) is a development of 3D models to add cost, time and management to the project dimensions to simulate the stages of design, construction and operation over the life of the project, so that it supports project management in several areas and different environments; as it builds an accurate representative model for all parts of the project in an integrated environment, which increases the efficiency and value of the project.[2].

Previous studies have shown many barriers to the application of BIM technology concerning knowledge of technology, technical, procedural, administrative, legal and cultural constraints, as well as training and learning constraints [3].

2 Study problem

Construction projects in Kuwait (especially large ones) need technology that supports the full coordination between the project stakeholders, reducing the cost and ideal modeling of the project, which contributes to reducing the problems of implementation to a large extent, hence the importance of the study in examining the benefits of the application of (BIM) technology in construction projects and assessing the level of awareness of the importance of its application and obstacles to the implementation of technology in Kuwait. .

The problem of the study lies in the search for ways to apply BIM technology in construction projects in the State of Kuwait.

3 Study questions

Considering the presentation of the study problem, the main questions posed by the study can be summarized as follows:

1. What is the importance of applying BIM technology in Kuwait?
2. How awareness is the application of BIM technology in Kuwait?
3. What are the barriers to the application of BIM technology in Kuwait?

4 Study hypotheses

The research relied on the following hypotheses:

1. A direct relationship between the degree of awareness

of BIM technology and the importance of its application.
2. A direct relationship between the application of BIM technology and the return on construction projects.
3. An inverse relationship between the degree of awareness of BIM and the constraints of its application.

5 Study objectives

The study aims to:

1. Learn about the features that will convince construction workers to apply BIM technology.
2. Identify the constraints of applying BIM technology in the construction industry.
3. Estimating the degree of awareness of participants in the construction industry with BIM technology
4. Develop appropriate solutions to overcome the obstacles of the application of BIM technology in Kuwait.

6 The importance of study

The importance of the study lies in the following:

1. The scarcity of studies dealing with the application of BIM technology in the construction sector in Kuwait and therefore covers an important research aspect.
2. The study deals with BIM technology, which is one of the most important technologies that contribute effectively to the management, coordination, and reduction of the cost of projects.
3. The study highlights the importance of BIM technology and its benefits at all stages of the project from design, analysis, construction, operation, and management.
4. It seeks to confirm the link between the lack of awareness of BIM technology and its spread in Kuwait.
5. Documenting the obstacles to the application of BIM technology in Kuwait.

7 Study limits

A study was conducted to evaluate the use of BIM technology at the level of representatives of contracting companies, consulting offices, real estate owners and engineering, and technical education institutions in the construction sector in Kuwait.

8 Study methodology

The study followed the descriptive analytical approach to achieve the goals using the questionnaire as a tool. it included many parties related to the construction of projects from consultant engineers, contractors, and technical training workers in Kuwait.

The questionnaire was prepared with the guidance of the results of previous studies and the study hypotheses. it consists of multi-choice questions covering all elements of the study. it included the nature of the work of the respondent for the questionnaire and the degree of awareness of technology and its importance and constraints.

9 Literature review

9.1 Definition of BIM technology:

BIM technology can be defined as using an electronic model to simulate the construction and operation of facilities to produce a digital representation of the physical and functional characteristics of the facilities that serves the different needs of the project parties [4]. It is a sharing technology for all the information about the project to make decisions based on real information, in addition to activating good coordination between the parties of the project throughout its life[5].

Many researchers have conducted studies to explain the principle of BIM technology and have defined the technology in many ways according to their awareness and different experiences. BIM technology has many important functions that can be applied at all stages of the project: design, implementation, and operation, resulting in the multiple benefits; as it was used to collect, use and share information to model. Also, it enables project simulation, evaluation and support manufacturing and procurement processes for products involved in construction [6].

BIM technology has not only modelled the origin and the introduction of its information, but it has also raised the quality and efficiency of constructions management.

9.2 Types of BIM technology

BIM technology includes several types as follows:

1. 3D means in standard dimensions of length, width, and height.
2. 4D is 3D plus time to plan and schedule the project.
3. 5D is four-dimensional plus cost.
4. 6D is a five-dimensional plus location (geospatial project coordinates) and needs integration between GIS and BIM technology
5. 7D includes management throughout the life of the project.

It could also include other dimensions covering project information (Jung and Joo [7]). Contractors could add cost and time factors to the model to facilitate value engineering studies, quantities surveying and project simulation.

9.3 Uses of BIM technology

BIM technology enables owner to see the project's perspective which can be used in marketing, while the designer prepares design ideas using technology as well as analysis, conflict detection and selection of raw materials (Olofsson, Lee [8]). Its uses can be summarized as follows:

1. Preparing perspective and video for the project before construction.
2. Discover conflicts between different disciplines of the project.
3. Simulate the project to make decisions.

4. Inventory and pre-manufacturing of raw materials and project inputs.
5. Planning, managing the project and preparing security instructions on the site [9]
6. Show the project timeline in the implementation stages.
7. Calculating the quantities and cost of the project as soon as the project is completed.
8. Project management, operation, and maintenance works after turning over the project.

Table (1) shows examples of BIM technology uses at different stages of the project.

TABLE 1
BIM TECHNOLOGY FUNCTIONS AT DIFFERENT STAGES OF THE PROJECT

Stage	BIM functions
Design	Modeling - spatial programming – disciplines coordination
Analysis	Structural analysis - energy analysis - lighting analysis - checking on the model - code for items.
Implementation	Site organization - time and cost simulation of construction stages - processing project materials and pre-manufacturing.
Operation	Scheduling maintenance work - operational management.
Management	Data sharing - modifications to the project plan - registration and follow-up - linking to databases.

Therefore, BIM technology has extensive applications at all stages of the project. Each specialist can work within the scope of his work and coordinate with the other project stakeholders.

9.4 The impact of BIM technology on the construction sector

BIM technology has covered all stages of the project. it increases efficiency, accuracy, speed of completion, coordination between the parties of the project. Also, it provides optimal use of energy, cost reduction, good monitoring of the project schedule (Mandhar and Mandhar [10]). In addition, it supports important in managing communications and sharing information for large projects to serve all parties of the project.
BIM technology helps many organizations and companies to increase the efficiency of their products and services, and to activate the integration of needs and operations for all construction processes; as the technology includes frameworks and technology to coordinate processes and information over the life of the project [11]. BIM technology has contributed to raising the value of the facilities, the reduction of construction time and give a realistic cost and multiple marketing options, as well as it is a reference in the processes of quality control and reduction of waste in raw materials and energy saving over the life of **(Kolpakov [12]).**

9.5 Advantages of BIM technology application in the construction sector

The main advantage of BIM technology is the accurate realistic representation of all parts of the building in an integrated information environment [13]. Three different study cases were modelled for projects with the same specifications: the first cases of a project with BIM technology fully, the second for a project with conventional technology, and the third In a mixture between both cases, (barlish Barlish and Sullivan [14]. Design and construction cost was compared including change orders in the three cases, the results of the study indicated significantly positive returns on cost and time as a result of the adoption of BIM [15]
Advantages of BIM technology can be summarized as follows:

1. The speed and effectiveness of the processes within the project for easy sharing of information with the project parties.
2. Design efficiency as a result of building analysis, presentation of various alternatives, quick simulation [16] and performance expectations, which helps to make improvements and innovative solutions.
3. Cost control and environmental performance forecasting of the building [17]
4. Raise the quality and productivity of the project for easy document extraction and better use of automation.
5. The efficiency and speed of manufacturing and assembling the project requirements.
6. To provide better service to customers where the project is presented with all the perspectives, kinetic representation and details allowing them a better understanding of the project.
7. Information support throughout the life of the building in the stages of design, construction, operation, management, and development.

Other studies also listed the benefits of BIM application: in a more realistic vision of the building, raising the quality of the project, raising the efficiency of analysis, studying the risks in the early stages of the project, meeting the requests for information immediately, and developing multiple alternatives to the development of the project [18]
BIM technology not only provides staff with all data including quantities, cost, time program, materials and decision-making support, but also has significant impact on the analysis of construction data and the preservation of the surrounding environment [19].
By implementation BIM technology, the effort is concentrated at the design phase to prepare the project model while the effort is significantly reduced in the later stages, while the tra-

ditional methods have a significant effort in the implementation phase, which reflects negatively on the cost, as well as the difficulty and high cost of adjustments at this stage [20].

9.6 Benefits of previous studies and what the current study adds

Previous studies have been used to develop the research framework and the selection of the method and study tool, as well as knowledge of the types of information modelling technology and its multiple uses, and the impact of its application in the construction stages.
The study adds the application of BIM technology at the level of Kuwait in a framework that combines several fields: the degree of awareness of the technology application importance, the importance of its applications and the obstacles to its application and appropriate solutions.

10 Questionnaire design

According to the results of previous studies presented on the use of BIM technology in construction, a two-section questionnaire has been prepared, with the first section containing data on the respondent and his field of work, while the second section contains 16 questions. An estimated balance was adopted according to the five-point likert scale to assess the participant's response to each item. Table (2) shows questionnaire fields and response levels for each field the response levels for each field.

TABLE 2
QUESTIONNAIRE FIELDS AND RESPONSE LEVELS FOR EACH FIELD

Specialists in the construction sector conducted face validity of the questionnaire for the state of the study and conducted a preliminary test of the questionnaire to remove any ambiguity or confusion with the questions as it was prepared in its final form and published.

Field	Response levels				
Awareness of BIM	V. strong	Strong	Moderate	weak	V. weak
The importance and advantages of using BIM	V. important	important	Moderate	Low	unimportant
Barriers to the implement ation of BIM	V. strong	Strong	Moderate	weak	V. weak
	1	2	3	4	5

11 Study and results

11.1 Statistical processing

The questionnaire included an independent variable, the field of work, and the set of dependent variables, which included questionnaire questions (16 questions) on three fields as presented in the questionnaire design.
The questionnaire was statistically processed using the arithmetic average, standard deviation, Cronbach's alpha coefficient for stability measurement. Pearson correlation coefficient was calculated to measure internal consistency, and a balance was adopted to evaluate responses by the Five Point Likert scale.

11.2 Sample study

The questionnaire was filled out by (37) construction specialists in Kuwait distributed as follows:

- (17) Consultant engineers
- (15) Contractors
- (5) Technical instructor

The results of the questionnaire were analyzed, and statistical processing was carried using SPSS program and the results were as follows:

11.3 Internal reliability

The questionnaire was presented to a group of specialists working in construction industry in Kuwait, where the fields and items were reviewed to ascertain their relevance and their relationship to the field of study. Some items were excluded, and others were added to make the necessary adjustments and then publish the questionnaire.

11.4 External reliability

The correlation coefficient between items and fields was calculated using SPSS to ensure that the items of each field were consistent. Table (3) shows the correlation coefficients of the questionnaire items.

The table shows the correlation of items and fields, with the correlation coefficient ranging from 0.736 to 0.965 at the significance level of 0.01, confirming the validity of the questionnaire.

TABLE 3
THE CORRELATION COEFFICIENTS OF THE QUESTIONNAIRE ITEMS

Field	Item	Correlation coefficient	Statistical significance
Awareness of BIM	1	0.74	0.01
	2	0.915	0.01
	3	0.736	0.01
The importance and advantages of using BIM	1	0.928	0.01
	2	0.896	0.01
	3	0.935	0.01
	4	0.965	0.01
	5	0.927	0.01
	6	0.867	0.01
Barriers to the implementation of BIM	1	0.789	0.01
	2	0.777	0.01
	3	0.758	0.01
	4	0.798	0.01
	5	0.815	0.01
	6	0.918	0.01
	7	0.912	0.01

11.5 STABILITY MEASUREMENT

The questionnaire stability was measured using the Cronbach's alpha coefficient for each field and whole questionnaire, the results were as follows:
The first field (estimating the level of awareness of BIM technology in construction): stability factor = 0.719
The second field (discovering the importance and advantages of using BIM technology in construction): stability coefficient = 0.963
Third field (assessment of barriers to implementation of BIM technology in Kuwait): stability factor = 0.918
Full questionnaire: Stability coefficient = 0.861
From previous results, the stability and validity of the questionnaire is clear to measure the objectives of the study.

11.6 THE FIRST FIELD: ASSESSING THE LEVEL OF AWARENESS OF BIM

The first field included three items to measure the level of awareness of BIM technology. Table (4) shows the analysis of the first field items and the weighted average of the field.
From the results of the previous table, it is clear that the degree of knowledge of the use of BIM technology in construction industry is moderate. it may refer to the implementation of BIM technology in some large projects, but the degree of awareness of the importance of its use and its benefits on projects, especially medium and small in general, is weak. The overall weighted average of the first field indicates a poor level of awareness and application of BIM technology in Kuwait.

TABLE 4
STATISTICAL ANALYSIS OF THE FIRST FIELD ITEMS

Item	Response levels					Weighted average	Standard deviation	Secular Trend
	Never	Weak	Moderate	strong	Very strong			
Degree of knowledge of the use of BIM technology	11.8	35.3	29.4	23.5	0	2.65	0.93	moderate
Degree of awareness of the use of BIM technology	11.8	35.3	35.3	17.6	0	2.59	0.84	Weak
Implementation of BIM technology in Kuwait	29.4	23.5	23.5	23.5	0	2.41	1.02	Weak
Weighted average of first field						**2.55**		**Weak**

11.7 THE SECOND FIELD: DISCOVERING THE IMPORTANCE AND ADVANTAGES OF USING BIM

The second field included six items to measure the importance and advantages of BIM technology in construction industry. Table (5) shows the analysis of the second field items and the weighted average of the field.

From the results of the previous table, it is clear that the great importance of BIM technology in the construction industry was the design, simulation of the project, analysis, coordination and communication between the project stakeholders, since most of the project obstacles are due to the lack of complete perception of the project and the lack of coordination between the project stakeholders, while the importance of technology in construction and preservation of the environment is decreases. it may refer to the lower importance of BIM at the execution phase compared to the design phase where many operational problems are avoided by raising the quality of the project design. in addition, the existence of environmental design programs reduces the importance of BIM technology to some extent in this field. The overall weighted average of the second field (4.29) indicates the great importance of BIM technology and its benefits in Kuwait in general.

TABLE 5

STATISTICAL ANALYSIS OF THE SECOND FIELD ITEMS

Item	Response levels					Weighted average	Standard deviation	Secular Trend
	Never	Low importance	Medium importance	Important	Very important			
BIM importance in design, simulation and analysis	5.9	0	0	35.3	58.8	4.41	0.98	Very important
BIM importance in coordination and communications	5.9	0	5.9	26.2	0	4.38	1.03	Very important
BIM importance in cost control and quantities surveying	0	0	5.9	51.1	43	4.37	0.89	Very important
BIM importance in planning and management	5.9	0	0	47.1	47.1	4.29	0.73	Very important
BIM importance in execution and decision support	0	5.9	5.9	52.9	35.3	4.18	0.94	Important
BIM importance in environment preserving	0	5.9	29.4	11.8	52.9	4.12	1.09	Important
Weighted average of second field						4.29		Very important

11.8 THE THIRD FIELD: BARRIERS TO BIM TECHNOLOGY IMPLEMENTATION IN KUWAIT

The third field includes seven items to measure the barriers of BIM technology implementation in Kuwait. Table (6) shows the analysis of the third field items and the weighted average of the field.

From the previous table, the obstacles of BIM technology implementation in Kuwait were arranged as follows:

1. Lack of BIM understanding & experience.
2. Absence of binding regulations related to BIM.
3. Institutional satisfaction with the current situation
4. Lack of BIM knowledge among projects owners
5. Lack of training & qualified workers
6. Neglecting of building's monitoring over its life
7. Lack of financial resources

From the result analysis of the third field, it was deduced that the strong obstacles of BIM technology implementation in Kuwait were the lack of understanding, awareness, and experience of technology, which is confirmed by the results of the first field of the study. It indicates the lack of awareness of BIM technology generally in Kuwait. Also, the absence of binding regulations to implement BIM in projects contributes to the lack of BIM implementation in institutions. in addition, one of the important barriers was the institutional satisfaction with the current situation to save time and the cost of training of their employees, while the importance of other obstacles such as lack of training and lack of financial resources was moderate. It may refer to the ease of solving these obstacles.

TABLE 6

STATISTICAL ANALYSIS OF THE ITEMS OF THE THIRD FIELD

Item	Response levels					Weighted average	Secular Trend
	Never	Weak	Moderate	strong	Very strong		
Lack of BIM understanding & experience	0	17.7	17.6	29.4	35.3	3.82	Strong
Absence of BIM binding regulations	0	17.7	29.4	29.4	23.5	3.59	Strong
Institutional satisfaction with the current situation	0	17.7	29.4	35.3	17.6	3.53	Strong
Lack of BIM knowledge among projects owners	5.9	17.6	23.5	47.1	5.9	3.29	Moderate
Lack of training & qualified workers	11.8	23.5	11.8	35.3	17.6	3.24	Moderate
Neglecting of building's monitoring over its life	5.9	23.5	35.3	23.5	11.8	3.12	Moderate
Lack of financial resources	5.9	29.4	23.5	41.2	0	3	Moderate

12 STUDY RESULTS

1. All previous studies have shown that BIM technology has transformed the construction industry in all stages starting from planning, design, analysis, coordination, execution, operation, data management and maintenance. It has many advantages for the projects: the

speed, effectiveness of operations, easy sharing of information with project stakeholders, design efficiency in building analysis, presentation of different alternatives, and rapid simulation and forecasts Performance which helps to make improvements and innovative solutions. In addition, BIM technology controls the cost, predicts the environmental performance of the building, raises the quality and productivity of the project, and provides better service to customers where the project is presented with all perspectives, dynamic representation, and details for better understand the project. Also, BIM technology provides information support throughout the life of the building.

2. One of the most important features of BIM technology in construction design is coordination between different disciplines and errors detection before commencement of the project. Also, Materials and supplies can be selected before project start to suit the design and full vision of the project. In addition, cost can be updated in real time.

3. BIM technology contributed to increasing profitability, reducing the completion time, and raising the efficiency of marketing; thus, it improves the return on investment for companies. The efficiency of communication between the project stakeholders and coordination among them were increased. Also, accuracy of time programs and estimation of the costs and quantities were increased which helps in making the right decisions. In addition, BIM technology provides effective management of existing facilities where the building is represented with all its materials, equipment; thus, it provides a realistic, updated, and accurate database through which any required information can be extracted quickly, accurately, and easily It helps controlling the operation and maintenance of the building.

4. The study results showed the low level of awareness and knowledge of BIM technology in the construction industry in Kuwait generally, which led to weak implementation of BIM, it refers to the lack of publicity for the importance of technology and its benefits in construction industry.

5. The relative importance of BIM technology benefits is arranged as follows:
   - Design, simulation, and analysis.
   - Coordination and communication between the project stakeholders.
   - Controlling cost and providing real time bill of quantities.
   - Planning, operation, and data management.
   - Execution follow up and supporting decision maker.
   - Preserving the environment by environmental design.

6. The relative importance of the obstacles to the BIM technology implementation were arranged as follows:
   - Lack of BIM understanding & experience.
   - Absence of binding regulations related to BIM.
   - Institutional satisfaction with the current situation
   - Lack of BIM knowledge among projects owners
   - Lack of training & qualified workers
   - Neglecting of building's monitoring over its life
   - Lack of financial resources.

7. The major obstacle against implementation of BIM technology in Kuwait was the lack of understanding and awareness about technology, which is confirmed by the results of the first study field, in addition to the absence of binding BIM related regulations; thus, it led to neglecting of technology implementation at different institutions, in addition to the satisfaction of those institutions in the current situation to save time and the cost of training for their employees. The importance of lack of training and financial resources was very low as they are not significant obstacles in Kuwait.

8. There is an inverse relationship between the level of awareness of BIM technology and the obstacles to its application; thus, raising awareness leads to overcome those obstacles. Also, there is a direct relationship between the importance of BIM technology and the level of awareness of technology, where the level of awareness increases the importance of technology because of the urgent need to solve the problems of the construction industry and raise its efficiency.

13 RECOMMENDATIONS

1. The necessity of training workers in the construction industry on BIM technology and its programs. Also, BIM must be incorporated in educational courses in universities and specialized academic institutions. Also, there is a need to collaborate with qualified companies to provide the necessary support to implement BIM technology.

2. Activating the role of the Society of Engineers and non-governmental specialized organizations in raising awareness and spreading BIM technology by holding workshops, training courses for all sectors of construction industry: planning, design, implementation, management, operation, maintenance, and real estate developers.

3. Preparing and encouraging companies and institutions

in construction industry to shift from the use of traditional programs such as AutoCAD to programs that work in accordance with BIM technology by gradually transferring after completing all the necessary preparations including training, technical support, software, and qualification for workers to accept the smooth transition to BIM technology. it can be applied to a limited number of projects initially and then gradually transition to all projects.

4. Effective government role is required to support BIM technology implementation by issuing binding regulations to use it in large projects of a special nature; hence, linking BIM implementation to obtain approvals and licenses from municipality and government agencies concerned. It can then be a gradual transition to implementation of technology to the rest of the projects in conjunction with preparation of specifications, codes and contracts regulating the use of technology in the construction industry.

5. it is recommended to provide the necessary financial resources to start the implementation of BIM technology and technical support to institutions and stakeholders. Also, it is required to choose the appropriate programs and techniques for implementation and prepare all the necessary documents and contracts.

6. it is recommended to carry out further BIM studies in all construction industry such as design, operation, and maintenance. In addition, comparative studies are required to hold a comparison between projects constructed with traditional technology and other similar projects constructed with BIM technology.

REFERENCES

[1] Smith, J., et al., Auditing construction costs during building design. Managerial Auditing Journal, 2004. 19(2): p. 259-271.
[2] Abbasnejad, B., H.I.J.I.J.o.E.R. Moud, and Applications, BIM and basic challenges associated with its definitions, interpretations and expectations. International Journal of Engineering Research and Applications (IJERA), 2013. 3(2): p. 287-294.
[3] Joannides, M.M., et al., Implementation of building information modeling into accredited programs in architecture and construction education. International Journal of Construction Education and Research, 2012. 8(2): p. 83-100.
[4] Succar, B.J.A.i.c., Building information modelling framework: A research and delivery foundation for industry stakeholders. Automation in Construction, 2009. 18(3): p. 357-375.
[5] Azhar, S., et al., Building information modeling for sustainable design and LEED® rating analysis. Automation in Construction, 2011. 20(2): p. 217-224.
[6] Gu, N. and K.J.A.i.c. London, Understanding and facilitating BIM adoption in the AEC industry. Automation in Construction, 2010. 19(8): p. 988-999.
[7] Jung, Y. and M.J.A.i.c. Joo, Building information modelling (BIM) framework for practical implementation. Automation in Construction, 2011. 20(2): p. 126-133.
[8] Olofsson, T., G. Lee, and C. Eastman, case studies of BIM in use. Electronic journal of information technology in construction, 2008. 13: p. 244-245.
[9] Zhang, J. and Z.J.A.i.c. Hu, BIM-and 4D-based integrated solution of analysis and management for conflicts and structural safety problems during construction: 1. Principles and methodologies. Automation in Construction, 2011. 20(2): p. 155-166.
[10] Mandhar, M. and M. Mandhar, BIMing the architectural curricula: integrating Building Information Modelling (BIM) in architectural education. International Journal of Architecture, 2013. 1(1): p. 1-20.
[11] Khosrowshahi, F., Y.J.E. Arayici, Construction, and A. Management, Roadmap for implementation of BIM in the UK construction industry. Engineering, Construction and Architectural Management, 2012. 19 (6): p. 610-635.
[12] Kolpakov, A., Green is good. BIM Journal, 2012. 3(30): p. 49-54.
[13] Sebastian, R.J.E., construction and a. management, Changing roles of the clients, architects and contractors through BIM. Engineering, Construction and Architectural Management, 2011. 18 (2): p. 176-187.
[14] Barlish, K. and K.J.A.i.c. Sullivan, How to measure the benefits of BIM—A case study approach. Automation in Construction, 2012. 24: p. 149-159.
[15] Lin, Y.-C.J.J.o.C.E. and Management, Construction 3D BIM-based knowledge management system: a case study. Journal of Civil Engineering and Management, 2014. 20(2): p. 186-200.
[16] Hu, Z., et al., Construction process simulation and safety analysis based on building information model and 4D technology. Tsinghua Science and Technology, 2008. 13(S1): p. 266-272.
[17] Wong, K.d. and Q.J.F. Fan, Building information modelling (BIM) for sustainable building design. Facilities, 2013. 31 (3/4): p. 138-157.
[18] Azhar, S.J.L. and m.i. engineering, Building information modeling (BIM): Trends, benefits, risks, and challenges for the AEC industry. Leadership and Management in Engineering, 2011. 11(3): p. 241-252.
[19] Farnsworth, C.B., et al., Application, advantages, and methods associated with using BIM in commercial construction. International Journal of Construction Education and Research, 2015. 11(3): p. 218-236.
[20] Ku, K., M.J.I.J.o.C.E. Taiebat, and Research, BIM experiences and expectations: the constructors' perspective. International Journal of Construction Education and Research, 2011. 7(3): p. 175-197.