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# The Benefits of and Challenges to Implement 5D BIM in Construction Industry

Amjed N.Hasan [a*], Sawsan M. Rasheed [b]

[a] *MSc Student, Department of Civil Engineering, University of Baghdad, Baghdad, Iraq.*

[b] *Assistant Professor, Department of civil Engineering, University of Baghdad, Baghdad, Iraq.*

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**Abstract**

The Architecture, Engineering and Construction (AEC) industry is known as one of the prominent sectors contributing to economic in Iraq. On the other hand, this sector suffers from poor quality, poor communication, and cost overruns and delay project completion. Time and cost estimation are two major critical processes in construction management, to conduct estimation must plans and specification are completed. Manually estimate is time consuming and error prone because human activities. Building information modelling (BIM) can be used to automate these processes in short time and accurate estimate, BIM is a relative new technology in architect, engineering, and construction industry (AEC), which has a major effect in construction industry practices. The 3D model is the geometry model and when attached time will be 4D and 5D when attached cost. The aim of this study is to provide clear understanding about 5D BIM in Iraqi construction industry by investigating benefits, challenges, and motivation factors that helps in applying it. The results show that the awareness rate of Iraqi engineers about BIM is actually weak with 67.5% of respondents, main advantages of BIM technology are collaboration, digital representation, visualization, effective QTO tool, and reduce change order, respectively, the main challenges that facing BIM are culture resistance, thoughts recent software and traditional approach are enough of 5D BIM tools, respectively; the main motivation factors that help in BIM adoption are adapted in universities and government support. The Iraqi construction industry is remained behind in adopting the BIM capabilities related to time (4D BIM) and cost management (5D BIM). This research helps as a stepping-stone to study further to promoting BIM application in the Iraqi construction industry.

*Keywords:* BIM; 5D BIM; 5D BIM Adoption; Benefit and Challenge of 5D BIM.

## 1. Introduction

Construction industry is one of the most important industries in the world; it suffers from poor communication, low productivity, and time and cost overruns [1]. The successful of building projects need more collaboration of different disciplinary by sharing accurate, continuous, and real- time information among project team to overcome conflicts and keep project on time and budget, poor communication and data management costs construction industry about 15.8 $ billion per year, 3-4 % of total turnover [2]. The construction industry tends to use technology in construction project to increase the productivity and quality of the project, reduce the cost of the project, and reduce the project time [3].

Building information modeling (BIM) which is a technology based-information of each element of building that helps in planning, designing, and managing the project in collaboration and coordination environment. Building

* Corresponding author: amjednaeem9@gmail.com

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information modeling (BIM) is a digital representation of a building's geometric and non-geometric data, and is used as a reliable, shared knowledge resource to make decisions on a facility throughout its lifecycle [4].

The use of BIM in several countries is continuous in growing. According to survey about BIM adoption rate in North America founded that 67% of engineers, 70% of architect, and about 74% of contractors used BIM [5]. In Australia, about 49% of architect and 75% of both engineers and contractors used BIM [6]. In UK according to national BIM survey found that 39% of respondents used BM. Year after year the use of BIM increase. There are many BIM applications [7] which can be used to support scheduling analysis, constructability, cost estimating and sequencing [8]. Building Information Modelling as a new paradigm has a great potential for integration into the life cycle of construction projects [9, 10].

One of the key benefits of BIM is the accurate geometrical representation of building components within an integrated information environment [11]. Additionally, the BIM decreases the duration and cost of the project, improves maintenance management and increases the value of the building [12]. On the other hand, the BIM as a new phenomenon seeks to renew the practices of the construction industry, so it is face to several obstacles facing its application [13]. For the implementation of BIM, this needs good planning and a coordinated approach with considerations for implementation and innovation management [14].

Iraqi construction sector suffer from poor quality, cost overruns, and delays in project completion, In Iraqi construction industry the use of BIM is very limited.This study focus on potential benefits and challenges of 5D BIM in Iraqi construction industry, in term of time dimension (4D) and cost dimension (5D). So this paper aims to assess the barriers and benefits of BIM. The objectives are: (1) to explore the extant literature for the obstacles and benefits to BIM implement. (2) To rank the barrier factors and benefits in terms of their importance levels; and (3) to assess the current knowledge with BIM in Iraqi construction sector.

## 2. Research Background

In last decade, the information technology (IT) especially building information modelling (BIM) consider one of the technologies that have a significant attention in construction industry. BIM presents huge opportunities and challenges, particularly in cost estimation aspect and quantity take-offs. Many researches have been focused on implement of BIM in construction industry in different stages of life cycle of project and studied the benefits and barriers.

2-1 BIM definition and concept

BIM is a virtual representation of a structure that contains all information that required for construct the structure, by using computer and software [15]. The physical characteristics attached to the component of the structure, when attached time to 3D give us the 4D model and when attached cost data give us 5D model or nD (for sustainability ,energy, facility management, …etc.). BIM can be summarized as the process and technology for producing, managing and sharing Functional and physical data of a facility in a cooperative environment using digital representative models throughout Lifecycle processes of the project [16].

### 2.1. Benefits of Implement 5D BIM

Many researchers have been studied the benefits of BIM. One of the most important benefits is the accurate of representation of building within an informative environment [11]. In BIM visualization it is possible to see the design in more detail and in a comprehensive way [17]. The design processes have become more efficient by using BIM, which gave the ability of dealing with informative environment design that allows simulating the model quickly and benchmarking performance [18]. In the same context, BIM supports to evaluate different design alternatives and study multiple scenario of the building design [19]. BIM also allows easy and quick extraction of any plans, details, and sections for the building without needing to draw it [20].

4D BIM model is useful in both design and construction stages; in design stage, it enables the owner to leverage great value out by visualizing construction sequences to develop phasing sequence in construction document. It can let the contractor to evaluate design by ensuring it that constructible and feasible. In construction stage, the 4D BIM model provides a better visualization of planned construction activities compared with actual, the contractor also can arrange site according to virtual 4D model such as location of movement and crew movement [21].

BIM can be used to generate quantities automatically from the model, The QTO generated by BIM tool from the model is more accurate than that extracted manually through traditional methods which it time consuming and error prone [12]. Cost estimation process manually is time consuming and error prone like any human activity, Emerging Building Information Modelling (BIM) can take advantage of standard method measurement to automate the cost estimation process and enhance the accuracy [22].

### 2.2. Challenges of Implementation 5D BIM

Although BIM offers many benefits to project, there are many challenges faces BIM implementation, Eastman et al. [12] and Aryaci et al.[23-24] showed several potential challenges of BIM implementation like resistance to change, adaption of existing workflow to lean- oriented programs, training of staff, understanding responsibilities, and lack of qualified staff. Kulven and Nyberg showed that most challenges to implement BIM were high expenditure education and culture resistance to change [25]. Some other barriers are the in compatibility of software, costs required to adopt this technology, and lack of presence of specialized instruction and standard [26].

Tulenheimo investigated challenges of implementation of BIM in construction engineering in Finland. The findings were 23 challenges that categorized in five groups including customers' expectations, company's own organizational context, social aspects, and information and communication technologies [27]. Navendren et al. investigate for discovering challenges of BIM implementation in UK design firms, the results showed that in these firms project-related, technology-related, cost-related, and training related are the most important challenges [28].

## 3. Research Methodology

The research followed the social science research technique. The literature review and interviews were found to be the most suitable approach for the research nature. The inductive "down-up" approach is adopted for this research as the type of the research is a learning process research that encourages the progress of the research from specific to general. An extensive literature review of relevant articles was conducted to build a strong understanding of the history, development, practices, tools, barriers, challenges of 5D BIM in construction and BIM implementation. The questionnaire was designed to identify how far the development of BIM adoption in Iraqi is, also to investigate the benefits gained by adoption 5D BIM and challenges that facing to adopt it in Iraqi construction sector.

The research includes three main stages which can be summarized in the following:

- The first stage: Includes highlighting the problem of the research, the aim from this research, setting objectives within the research plan and also identifying research hypotheses.
- The second stage: This stage includes the collection, analysis, and summarizes the literature that related to research topic and builds a theoretical framework derived from previous studies.
- Third stage: The design of the questionnaire, which includes the preparation of the main parts and the items and questions of each part after completing the draft of the questionnaire as a primary form through the following steps:
  a. Arbitration: the questionnaire was presented to experts from inside and outside Iraq, to show their opinions about the validity of the component of the questionnaire and then respond to the opinions of experts and the amendment to the light of their observations.
  b. The questionnaire was distributed to the whole sample that was 71 and the answers were 54.
  c. After that questionnaire data was prepared and organized for statistical analysis which included several tests by using (IBM SPSSv.24).

Figure 1 illustrates the research plan.

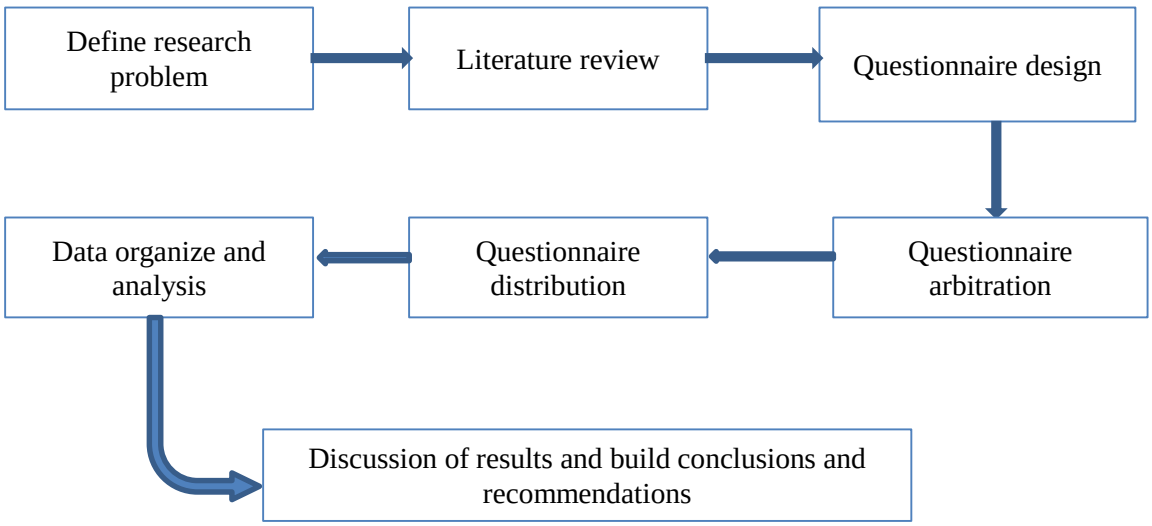


**Figure 1. Research plan**

he data were collected using the field survey through the design of a special questionnaire for this purpose as it mentioned previously, and this questionnaire distribute to the professionals working in the Iraqi construction sector in both public and private sectors. Participants explained their views in a set of items in the questionnaire, where 81 questionnaires were distributed, and the total return was 54. The questionnaire included five main parts: the first part is the personal information regarding the respondent including (gender, age, academic qualification, specialization, group, and work experience), the second part included questions to evaluate the current knowledge in BIM, third part included 19 items shown in Table 2 representing the 5D BIM potential benefits, fourth part included 13 items shown in Table 3 representing the BIM potential challenges, and last part included 7 items shown in Table 4 representing the 5D BIM motivation factors, which used in questionnaire and designed by the five- Likert scale as follow:

5. Extremely agree;

4. Agree;

3. Moderate;

2. Disagree;

1. Totally disagree.

After the collection of the questionnaires, they were arranged, unloaded and analysed using the Statistical Packaging for Social Science (SPSS) software version 24, to find descriptive statics and relativity importance index to rank them according to its importance.

## 4. Results and Discussion

### 4.1. Awareness Level of BIM and its Usage

In questionnaire asked several question to know the knowledge and awareness of respondent in BIM generally and 5D models especially, the results show low awareness in knowledge of BIM about 21% used BIM in their companies and 34% has been rarely or even unrecognized in their organizations and about 55% yet they have not implemented or planned to adopt BIM in their practice 15% used BIM in quantity take off and estimating. The Revit BIM tool was the more usage and familiar to respondents, respondents answer that most three benefit of BIM are clash detection, reduce re-work and cooperation, respectively; while top three challenges were resistance to change, government support, and initial cost, respectively. Table 1 shows the demographic characteristics of target respondents.

**Table 1. The Respondent's Profile**

| Information about | Categories | Percentage |
|---|---|---|
| Gender | Male | 79.6 |
| | Female | 20.4 |
| Job Sector | Public | 24.1 |
| | Private | 64.8 |
| | Mixed | 11.1 |
| Qualification | BSc. | 51.9 |
| | MSc. | 42.6 |
| | PhD. | 5.6 |
| Specialization | Architect | 13.0 |
| | Civil | 79.6 |
| | Mechanical | 3.7 |
| | Electrical | 3.7 |
| Job title | Design | 20.4 |
| | Planning | 22.2 |
| | Consulting | 11.1 |
| | Site | 29.6 |
| | Q.S | 16.7 |
| Year experience | Less than 5 years | 22 |
| | 5 to 10 | 22 |
| | 10 to 15 | 24 |
| | 15 to 20 | 15 |
| | More than 20 | 17 |

## 4.2. Benefit of Using 5D BIM

Participants' level of agreement (1=Strongly Disagree, to 5=Strongly Agree) with statements relating to their perceptions regarding the benefits of 5D BIM implementation, the answers as shown in Figure 2.

This part contains 19 items representing the potential benefits of BIM that extracted and conclude from literature review. After exposure to the opinion of the respondents were analyzed and extracted their results and these results included, Relative Importance Index RII.

$$RII=\Sigma W/(A*N) \quad (1)$$

The questionnaire asked participants to indicate their level of agreement with statements derived from the literature that related to the benefits of using 5D BIM. The participants' overall ratings are identified in Table 2 below.

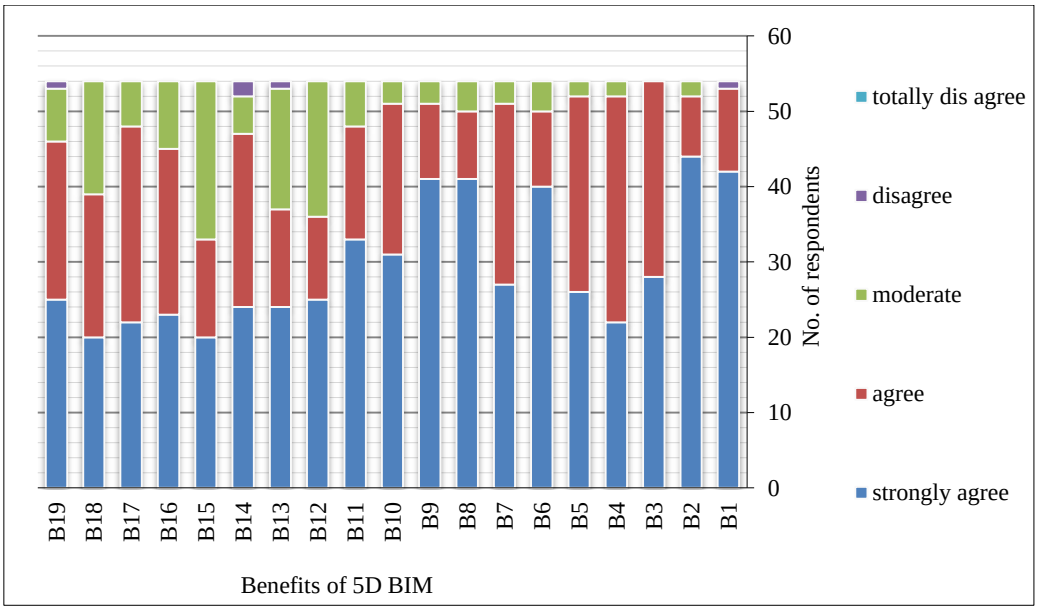


**Figure 2. Perceived benefits to BIM adoption in Iraqi construction sector**

**Table 2. Benefits of 5D BIM (n=54)**

| [NB: 1=Strongly Disagree, 5=Strongly Agree] | RII | Mean | Rank |
|---|---|---|---|
| Digital representation will increase understanding the project for best estimation of cost and time (B1) | 0.951 | 4.740 | 2 |
| More collaborative among project team (B2) | 0.955 | 4.777 | 1 |
| Link cost and time and other parameters in one model (B3) | 0.883 | 4.518 | 7 |
| More accuracy and quickly in calculating QTO than traditional methods (B4) | 0.864 | 4.370 | 11 |
| Early detect design error and clashes (B5) | 0.872 | 4.444 | 10 |
| Reduce change order (B6) | 0.925 | 4.666 | 5 |
| Link all disciplines in one environment work (B7) | 0.883 | 4.444 | 8 |
| Link the schedule to the 3D model in visualization way (B8) | 0.936 | 4.685 | 3 |
| 5D model gives effective QTO than ($/m$^2$) (B9) | 0.928 | 4.703 | 4 |
| Risk identification in early stage (B10) | 0.870 | 4.518 | 9 |
| Increase the ability of solving RFIs in short time (B11) | 0.906 | 4.5 | 6 |
| Visualization the schedule to stakeholder will increase their understanding and improve decision making (B12) | 0.811 | 4.129 | 16 |
| Easy in showing sequence of activities (B13) | 0.811 | 4.111 | 17 |
| Effective tool in solving dispute (B14) | 0.841 | 4.277 | 15 |
| Shorten time of project through coordination and prefabrication (B15) | 0.770 | 3.981 | 19 |
| Continuous feedback when design change (B16) | 0.849 | 4.259 | 13 |
| Reduce risks related to schedule and cost based on BIM-based planning (B17) | 0.849 | 4.296 | 12 |
| Comparing more than one scenario for schedule to comply with top management (B18) | 0.792 | 4.092 | 18 |
| Direct integration with construction activities like cost estimate, schedule, and QTO (B19) | 0.849 | 4.296 | 14 |

The results showed that the" more collaborative among project team" is the highest potential benefit from 5D BIM according to respondents, with (RII=0.955, mean=4.7778, SD=0.50157). Consider one of the most important features offered by the BIM. These findings as same of [29] that he thinks the using of 5D is very useful in cost modeling to encourage collaboration, and consist with many researchers likes [30, 31, 32]. And consist with Iraqi construction sector suffers from non-cooperation, and more of clashes between different disciplinary in execution phase.

The potential 5D BIM benefit which was in the second rank is" digital representation will increase understanding the project for best estimation of cost and time" with (RII=0.951, mean=4.7407, SD=0.55577). This result is consistent with the Iraqi construction projects suffer from cost overruns due to several factors mentioned by [33], and the same with several international research on benefit BIM [34]. The visualization of the facility in design stage give more understanding of project than traditional 2D which almost these project suffers from cost and delay overruns.

In the third rank is" Link the schedule to the 3D model in visualization way" with (RII=0.936, mean=4.6852, SD=0.60887). These findings sound consistent with [12], who shows QSs as being better able to understand project they are involved in, as they can see and interact with the 3D model.

In the fourth rank is"5D model gives effective QTO than ($/m$^2$)" with (RII=0.928, mean=4.7037, SD=0. 0.57065). The main advantage of BIM is quantity take off that extracted automatically from model which is more accurate and time consuming [35].

The fifth rank of 5D BIM potential benefits was" Reduce change order" with (RII=0.925, mean=4.6667, SD=0.6143). The change orders have a significant impact on increasing the cost and time of the project. This result is in same line with [36] findings of the benefits of BIM and consist with researchers from other countries [23].

It is important to note that there are no huge numerical differences among the identified benefits from rank 1 to 6. From this finding, it can be reasoned that the current low BIM adoption or limited investigation of advanced BIM capabilities in the Iraqi construction industry there is no real adoption plan although these benefits are realized from respondents.

### 4.3. Challenges of Using 5D BIM

Participants' level of agreement (1=Strongly Disagree to 5=Strongly Agree) with statements relating to their perceptions regarding the barriers to 5D BIM implementation, the answers as shown in Figure 3. To evaluate the ranks of potential challenges of 5D BIM that obtained from participant's answers, the relative important index was calculated to each item and ranked from the highest to lowest. See Table 3. The results showed that" culture resistance" is the highest potential challenge for BIM application according to the point of view of respondents with (RII=0.951, mean=4.6481, SD=0.73092). This finding is not sudden, as there has been agreement among many researchers that it is an important BIM challenge [37]. And that consist with Iraqi construction sector which most of it afraid of change. This may be top management are not heard about BIM and Iraqi construction sector totally depends on government support and financing, private sector needs more legislation and cooperation with public sector.

The second highest challenge was" companies think that have software more accurate than 5D software" with (RII=0.914, mean=4.5741, SD=0.83783). This is in the line of first highest challenge and consists with [38].

The third highest challenge was" lack in BIM contract" with (RII=0.814, mean=4.0741, SD=0.60973).

The fourth highest challenge was" lack of qualified staff to adopt this technology" with (RII=0.796, mean=3.9815, SD=0.73947) this result is consistent with findings Ali (2015) the lack of qualified and expertise staff in BIM field is one of the most important BIM challenges [39].

It is important to note that there are no huge numerical differences among the identified barriers from rank 1 to 4. From this finding, it can be extrapolated that the current low BIM adoption or limited exploration of advanced BIM capabilities in the Iraqi construction industry is not caused by only one single reason such as culture resistance, but it is caused by complex reasons which are a combination of various barriers including lack of qualified staff lack in BIM contract.

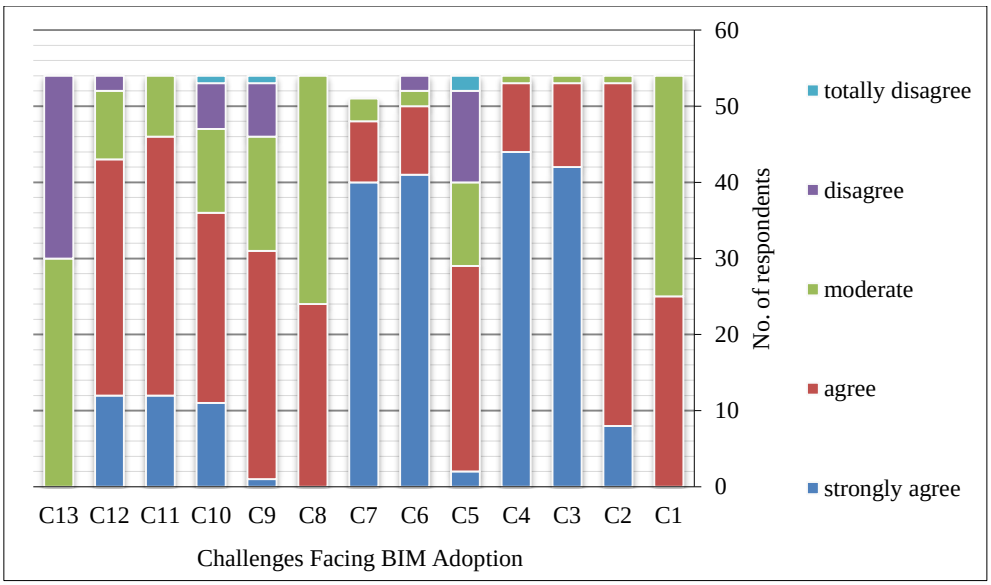


**Figure 3. Perceived challenges to BIM adoption in Iraqi construction sector**

**Table 3. Challenge of Using 5d BIM**

| [NB: 1=Strongly Disagree, 5=Strongly Agree] | RII | Mean | Rank |
|---|---|---|---|
| Initial cost to adopt BIM technology (C1) | 0.744 | 3.722 | 5 |
| Problems arise from interoperability (C2) | 0.548 | 2.740 | 11 |
| Initial cost of software to use this technique (C3) | 0.729 | 3.648 | 7 |
| The failure of compatibility between software (C4) | 0.470 | 2.351 | 13 |
| The risk arising from who has the model (C5) | 0.655 | 3.277 | 10 |
| Culture resistance in company prevent adoption of this technique (C6) | 0.951 | 4.648 | 1 |
| Thoughts of company that have of software is enough to adopt 5d BIM model (C7) | 0.914 | 4.574 | 2 |
| Lack of non- integration model design and lack on information needed to estimate quantity (C8) | 0.688 | 3.444 | 8 |
| Cost of updating software and hardware (C9) | 0.685 | 3.425 | 9 |
| Lack of protocol and criteria that related to BIM (C10) | 0.744 | 3.722 | 6 |
| Need to formulate contracts associated to BIM (C11) | 0.814 | 4.07 | 3 |
| Lack of qualified staff to adopt this technology (C12) | 0.796 | 3.981 | 4 |
| No real project constructed in BIM in Iraq (C13) | 0.511 | 2.555 | 12 |

## 4.4. Motivation Factors of 5D BIM

Participants' level of agreement (1=Strongly Disagree, to 5=Strongly Agree) with statements relating to their perceptions regarding the benefits of 5D BIM implementation, the answers as shown in Figure 4.

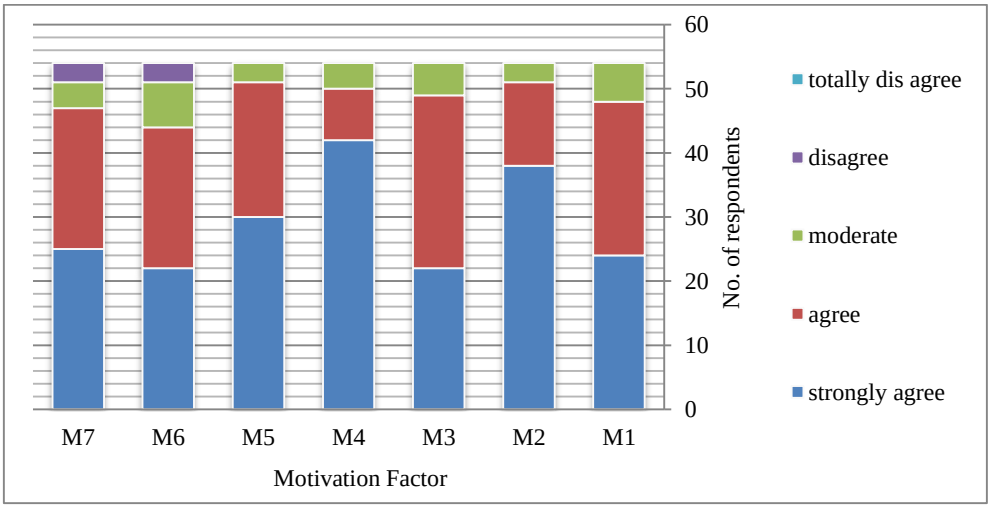


**Figure 4. Perceived to BIM adoption in Iraqi construction sector motivation factor**

To evaluate the ranks of motivation factors of 5D BIM that obtained from participant's answers, the relative important index was calculated to each item and ranked from the highest to lowest. See Table 4.

**Table 4. Ranks of BIM Motivation Factors Depending on RII**

| [NB: 1=Strongly Disagree, 5=Strongly Agree] | RII | Mean | Rank |
|---|---|---|---|
| Explain the importance of 5D BIM in conference and workshop | 0.866 | 4.333 | 3 |
| Teaching BIM technology in universities | 0.901 | 4.648 | 1 |
| Establish protocols for BIM | 0.814 | 4.333 | 4 |
| Publish periodic report and paper to show BIM practice | 0.773 | 3.703 | 7 |
| Government support in legislation that encourage adopt of BIM | 0.898 | 4.5 | 2 |
| Award the engineering design to company working with BIM | 0.788 | 4.074 | 6 |
| Employ youth engineer in both public and private sector who have the ability to apply this technology | 0.803 | 4 | 5 |

The results showed that "teaching BIM technology in universities" s the highest BIM motivation factor according to the point of view of specialists with (RII=0.901,mean=4.6481). This result is due to that Iraqi universities lack a course related to BIM and information technology, especially in the early stages of the study.

The second BIM motivation factor is “government support in legislation that encourage adopt of BIM” with (RII=0.898, mean=4.5) The Iraqi government has not exposed a unique role in the adoption and broadcasting of modern technologies in the field of the Iraqi construction sector, but there is a shy trying from ministry of housing and municipalities in training on BIM tools only and that not enough to adopt it. On the other hand, this result shows agreement with many researchers who have studied the BIM [18]. The responses from interviewees exactly echo with the findings from the literature review that there is a lack of government-led effort on mandating BIM for public construction projects, even though interviewees commonly mentioned that the BIM acceptance will be possibly increased by either clients’ demands or government’s intervention.

## 5. Conclusion

The perceptions of a questionnaire on the benefits of, and barriers to, the implementation of 5D BIM have been identified. Findings suggest that 5D-BIM may provide advantages over traditional approach in estimation by increasing collaborative among project team, increase understanding the project for best estimation of cost and time, increasing visualization of construction details and link 3D with time and cost, 5D model gives effective QTO, and Reduce change order. However there are perceived barriers to 5D-BIM implementation within the construction industry: culture resistance, companies think that have software more accurate than 5D BIM, lack of protocols for coding objects within building information model, and lack of qualified staff to adopt this technology. This research provides a benchmark against which to gauge changes in the use of 5D BIM for cost estimating, which could help find solutions to overcome these barriers to inter-operability between 3D and 5D BIM.

## 6. Acknowledgements

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## 7. Conflict of Interest

The authors declare no conflict of interest.

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