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Article

Barriers of Adoption Building Information Modeling (BIM) in Construction Projects of Iraq

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Abstract. Building Information Modeling (BIM) is a unified and comprehensive system for all that associated with the construction project, which includes a set of effective policies, procedures, and computer applications that increase the level of performance in construction project during its life cycle. Through this study investigate about the potential barriers which facing the adoption of BIM was performed. The quantitative approach was adopted by conducting a questionnaire directed to professionals in the field of construction projects in the public and private sectors. Three hundred copies of the forms were distributed to the private companies and governmental institutions and departments. The data were subjected to the appropriate statistical analysis and the results showed that the three highest potential barriers of using BIM in Iraq are a weakness of the government's efforts, Poor knowledge about the benefits of BIM, and resistance to change.

Keywords: Barriers, BIM, building information modeling, construction project, Iraq.

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1. Introduction

The construction industry has witnessed a paradigm shift that will achieve the highest performance on the level of efficiency, quality, productivity, sustainability, reducing cost, reducing time, raising the financial value of the project [1]. This is consistent with what Azhar [2] says about construction industry tends to implement techniques that reduce the cost of the project, increase the productivity and quality of the project and reduce the project time.

One of these techniques is building information modeling (BIM) which is a technological and procedural shift in the construction industry [3]. Actually, the evolution of computer science as well as information technology has caused a positive change in the processes that are related to most industries [4].

Building Information Modeling (BIM) is an advanced process and tool consisting of a combination of virtual aspects, systems and concepts facilitated within a unified environment [5]. It includes the application and keeps integrated digital representation of different information across different project stages [6].

There are many BIM applications [7] which can be used to support constructability, scheduling, analysis, cost estimating and sequencing [8]. Building Information Modeling as a new paradigm has a great potential for integration into the life cycle of construction projects [9, 10]. BIM can simulate project time and integrate it with the standard design model and in this context according to Naderpour [11] the time management can be effective in a project when the project schedule is based on comprehensive time scheduling.

One of the key benefits of BIM is the accurate geometrical representation of building within an integrated information environment [12]. Furthermore, the BIM reduces the duration and cost of the project, improves maintenance management and increases the value of the building [6]. Tomek [13] pointed out that BIM has impact on both external and internal risks in construction company. This is important according to what Rezakhani [14] says that due to unique properties of construction operations, many risk factors are involved in construction project.

BIM also improves communication between the different project parties [15]. On the other hand, the BIM as a new phenomenon seeks to renew the practices of the construction industry, so it is subject to several barriers facing its application [16].

2. Research Background

Various stakeholders in the AEC industry have recognized the benefits of BIM and this is why it was used in large projects such as (London Olympic Stadium), (Veldodrome cycle track), (The Cheese grater Building) in London [17]. In addition many complex projects that have successfully completed these projects such as (EMP museum), (Walt Disney Concert Hall), (Shanghai World Expo cultural center), (Shanghai tower) and other projects [18]. Thus, BIM has been widely implemented around the world, exclusively in developed countries. However, organizations and companies face a range of barriers in their BIM application [19].

It is difficult to convince private clients of the change toward BIM in a short time [18]. This is also consistent with what Eastman [6] says about clients as most of them prefer not to venture and wait to see the benefits and barriers of the BIM while being used by their competitors. On the other hand, the cost of the initial investment for the application of the BIM is high, as it requires huge funds to buy the software and hardware required by certain specifications in addition to the cost of training and the wages of specialists, all of these barriers to the application of BIM [17, 18].

In addition, weak support from senior management is one of the barriers facing the application of the BIM, as the main factor in the success of any change is the support of senior management which must exist to face the strong resistance to change [20].

After the completion of the project, the BIM model is delivered by the client to the facility management team who are responsible for the maintenance and operation of the building [21]. Although the client considered the ownership of the model belongs to him as he pays the price to the designers and parties responsible for producing the final model at the end of the project, but the researchers and specialists indicated to the unsafety the designers and parties involved in the production of the final model suffered in terms of ownership of their inputs [6].

One of the barriers facing BIM application is the fragmented nature of stakeholders where this barrier is incompatible with what BIM requires of cooperation in work [22]. On the other hand, each party involved in the creation of the BIM model uses specific software that suits with the required task and the difference between this software generates compatibility problems, which constitute a barrier to the exchange of data

to and from the model [17, 18].

On the legal side, the lack of BIM standard contracts is another barrier for many companies and organizations [23]. Table 1 in Appendix A summarizes the barriers of other researchers from different countries.

3. Research Methodology

This paper investigates about potential barriers that facing the adoption of BIM in Iraq. The data were collected through field survey by design a special questionnaire for this purpose distribution it to the professionals working in the Iraqi construction sector in both public and private sectors Respondents explained their views in a set of items in the questionnaire, where 300 questionnaires were distributed and the total return was 273 be response rate 87.7%. with 11 incompletes, so the final number of forms is 262 forms. The interview method is used in the distribution of the questionnaire. Kumar and Phrommathed [24] points out that the method of the interview gives a relatively high response rate and reduces the probability of incorrect or inadequate answers compared to other methods such as the online questionnaire. The method of the interview was in two ways, some governmental institutions provided facilities to hold a single seminar or multi seminars to discuss the subject of BIM and respondents fill out the questionnaire after the end of these seminars. Other firms did not provide facilities, or the number of their target respondents is small, resorting to the second method which is the direct interview with the respondent. Each respondent took about 6 to 8 minutes to fill out the questionnaire. The questionnaire included three main parts:

part I (General Information): This part comprises general information concerning the respondent (name, age, gender, and the type of work sector) in addition to the classifications of the educational qualification, specialization, job position and work experience.

part II (current practices and extent of BIM knowledge): This part was used to describe the current work practices, which included question about the type of projects managed by the firm or the company and the uses of the respondent from the CAD and request each respondent to determine the software on which it works, in addition to the question about how to document the projects data and information during the lifecycle of them , This part also includes the question the respondent about the BIM and have been heard in any way and whether it is used or not, in addition to the question of the extent to which it is known, and also to provide a 20-year time limit to assess the possibility of applying the BIM within this range.

part III (BIM protentional barriers): This part includes a list of the barriers facing the BIM. It contains (23) closed questions designed by the five- Likert scale [25]. The scale is (1: Very weak, 2: Weak, 3: Moderate, 4: Strong, 5: Very strong). Each respondent was invited to give a degree of measure to each question according to what he believes within the environment of the Iraqi construction sector.

After the collection of the questionnaires, they were arranged, unloaded and analyzed using the Statistical Packaging for Social Science (SPSS) software version 24.

4. Arbitration of the Questionnaire

The arbitration of the questionnaire is defined as an essential type of validity given by experts as a judgment on the instrument whether it measures what we perceive it to measure [26]. Accordingly, the arbitration was conducted to verify the validity of the questionnaire by presenting the questionnaire to three groups of experts and asked them to express their opinions and suggestions about the questionnaire.

The first group was asked to evaluate the questions of the questionnaire and their suitability for the scope of the research and whether the questionnaire questions reflect the concept of the research. All arbitrators from this group are those with prior knowledge of BIM and its software and with different levels.

The second group includes experts from the statistical field to assess whether the questionnaire was valid in terms of its design sufficiently to conduct statistical tests.

Finally, the third group asked for its opinion on the Arabic and English questionnaire languages and Table 2 shows the qualifications of all experts and their countries.

Table 2 Information about arbitrators.

| Group | Expert | Educational Qualification | Place of Work | Country of Expert |
|-----------|--------|---|---|-------------------|
| Content | C1 | Ph.D. in construction management | Middle Technical University | Iraq |
| | C2 | Ph.D. in Road and airport engineering | University of Diyala | Iraq |
| | C3 | Ph.D. in architectural engineering | University of Baghdad | Iraq |
| | C4 | Ph.D. researcher in construction management | Loughborough University | UK |
| | C5 | M.Sc. in construction management | University of Technology | Iraq |
| | C6 | M.Sc. in construction management | The Islamic University in Gaza | Palestine |
| | C7 | M.Sc. in construction management | Tishreen University | Syria |
| | C8 | Bachelor of Civil Engineering and Revit trainer | General Company for Technical Studies and Consultations | Syria |
| Statistic | S1 | Ph.D. in statistics | Swami Ramanand Teerth Marathwada University | India |
| | S2 | Ph.D. in statistics | International Islamic University Malaysia | Malaysia |
| Language | L1 | Ph.D. Arabic Language | University of Sulaymaniyah | Iraq |
| | L2 | M.Sc. English Language | University of Diyala | Iraq |

5. Pilot Study

A pilot study can be defined as a small initial study or trial attempt applied to respondents whose characteristics are similar to those of the original sample respondents [26, 27].

Salkind [27] points out that the main objective of conducting the pilot study is to discover the problems and identify the questions that are more ambiguous than others and this helps the researcher to take corrective practices that improve the research process.

The size of pilot study sample ranged between 30 and 50 respondents [28]. In this study the size of the sample is 40 collected and arranged for the purpose of processing the statistical tests. Based on what Krauth [29] pointed out, the pilot study data are used only to show whether the questionnaire is proper for distribution to the main sample (in terms of validity and reliability). Therefore, the sample of the pilot study should not be included in the main sample.

6. Statistical Validity and Reliability (According to Pilot Study)

Access to acceptable results within any research requires the use of accurate measurement instrument as one of the basic requirements. Behjati [30] mentions that among the main objectives of the researcher is to design his research tool and make it characterized by three main qualities (be meaningful, be accurate, be efficient). Therefore, the validity and reliability tests were conducted on the data obtained from the pilot study.

6.1. Statistical Validity

The validity of instrument can be defined as the degree to which the instrument measures what it is supposed to measure [31, 32]. Through this test, correlation coefficients between each item in a particular part are measured with the part as a whole [33].

The test was carried out on the parts that intended to measure the potential BIM barriers by calculating the correlation coefficients. Table 3 shows the values of the Spearman's Rho correlation coefficient (for ordinal) and p-values for all items of potential barriers part.

Table 3 Spearman's rho correlation for BIM potential barriers in pilot data.

| Barriers | Correlation Coefficient | Sig. (2-tailed) | Barriers | Correlation Coefficient | Sig. (2-tailed) |
|---|-------------------------|-----------------|----------|-------------------------|-----------------|
| BA1 | 0.372* | 0.018 | BA13 | 0.572** | 0.000 |
| BA2 | 0.491** | 0.001 | BA14 | 0.709** | 0.000 |
| BA3 | 0.468** | 0.002 | BA15 | 0.703** | 0.000 |
| BA4 | 0.422** | 0.007 | BA16 | 0.714** | 0.000 |
| BA5 | 0.492** | 0.001 | BA17 | 0.729** | 0.000 |
| BA6 | 0.440** | 0.004 | BA18 | 0.601** | 0.000 |
| BA7 | 0.520** | 0.001 | BA19 | 0.711** | 0.000 |
| BA8 | 0.524** | 0.001 | BA20 | 0.726** | 0.000 |
| BA9 | 0.680** | 0.000 | BA21 | 0.697** | 0.000 |
| BA10 | 0.322* | 0.043 | BA22 | 0.783** | 0.000 |
| BA11 | 0.486** | 0.001 | BA23 | 0.481** | 0.002 |
| BA12 | 0.536** | 0.000 | | | |
| *Correlation is significant at the 0.05 level (2-tailed) | | | | | |
| **Correlation is significant at the 0.01 level (2-tailed) | | | | | |

Results showed that correlation coefficients ranged from (0.322) to (0.783) and P- values, all than 0.05. This gives an indication that all items are consistent and have the valid to measures what has been set up to measure it.

6.2. Statistical Reliability

One of the most common methods of calculate reliability and the value of the Alpha Cronbach constant from 0 to 1 and the closer to 1 indicates the high degree of reliability [34].

Table 4 below represents a classification for the degree of reliability according to the value of the alpha-Cronbach coefficient.

When the Alpha Cronbach method was conducted for the questionnaire, the results is 0.916 which is within the excellent limit this result confirms the reliability of the questionnaire.

After ascertaining the validity and reliability of the questionnaire according to the results of pilot study analysis, the questionnaire became eligible for distribution with the main sample.

Table 4. Reliability cutoff values [34].

| Cronbach's alpha | Degree of Reliability |
|-------------------------|-----------------------|
| $\alpha \geq 0.9$ | Excellent |
| $0.9 > \alpha \geq 0.8$ | Good |
| $0.8 > \alpha \geq 0.7$ | Acceptable |
| $0.7 > \alpha \geq 0.6$ | Questionable |
| $0.6 > \alpha \geq 0.5$ | Poor |
| $0.5 > \alpha$ | Unacceptable |

7. Statistical Techniques Used for Questionnaire Data Analysis

A set of quantitative statistical techniques have been used to analyse the questionnaire data to obtain a comprehensive view of the opinions obtained from the specialists in Iraqi Architectural, Engineering, construction (AEC) regarding the subject of BIM potential barriers. These statistical techniques will be clarified Below:

Descriptive Statistics

Descriptive statistics can be defined as statistical methods which aims at summarizing data, organizing data, and simplifying data [35]. Descriptive statistics that have been used are:

Central Tendency Measurement

The central tendency of the statistic refers to the concept of representative value (the average), which aims to describe the distribution of values with the best single value, and one of the most important measures of central tendency is the mean [35].

Variability Measurement

Variability measures are quantitative measures intended to measure differences between values in a distribution and to indicate the extent to which the data is centered or dispersed, and one of the most important measures of Variability is the standard deviation (SD) [35].

Relative Importance Index (RII)

One of the techniques used in the analysis of data is the relative importance index RII and the purpose of its use is to give a rank for each item in a particular part in the questionnaire.

The equations:

$$RII = \frac{\sum W}{(A*N)} \quad (1)$$

$$RII = \frac{5(n_5)+4(n_4)+3(n_3)+2(n_2)+n_1}{5(n_5+n_4+n_3+n_2+n_1)} \quad (2)$$

where

W: The weight given by respondents for each component (ranging from 1 to 5);

A: Represents the highest weight (which equals 5);

N: Represents the total number of respondents.

8. Results and Discussion

8.1. General Information for Respondents

The demographic characteristics of target respondents shown in Table 5.

Table 5. The respondent's profile.

| Information about | Categories | Percentage |
|------------------------|-----------------------------|------------|
| Work sector | Public sector | 79% |
| | Private sector | 14% |
| | Public and private together | 7% |
| | | |
| Gender | Male | 69% |
| | Female | 31% |
| Age | 20-30 years | 25% |
| | 31-40 years | 51% |
| | 41-50 years | 18% |
| | More than 51 years | 6% |
| | | |
| Academic qualification | Diploma | 3% |
| | Bachelor | 80% |
| | Master | 10% |
| | Ph.D. | 10.6% |
| | Other | 1% |
| Specialization | Architect | 4% |
| | Civil Eng. | 52% |
| | Electrical Eng. | 24% |
| | Mechanical Eng. | 12% |
| | Other | 8% |
| Group (Job) | Designer | 14% |
| | Consultant | 9% |
| | Project manager | 10% |
| | Site engineer | 50% |
| | Contractor | 12% |
| | Other | 5% |
| Practical experience | Less than 5 years | 30% |
| | 5-10 years | 24% |
| | 11-15 years | 17% |
| | 16-20 years | 17% |
| | More than 20 years | 12% |

8.2. Current Practices and Level of BIM Awareness

To achieve a comprehensive view of the respondents' background and place of work, they were asked several questions related to the firm or company in which they work as well as other questions aimed at knowing the current status of BIM and the extent of knowledge available to it.

Figure 1 shows the type of the projects managed by the firm or company where the percentages as follow: Building projects equals 22.2%, infrastructure projects equals 30.9% and together (Building and Infrastructure) equal 46.9%.

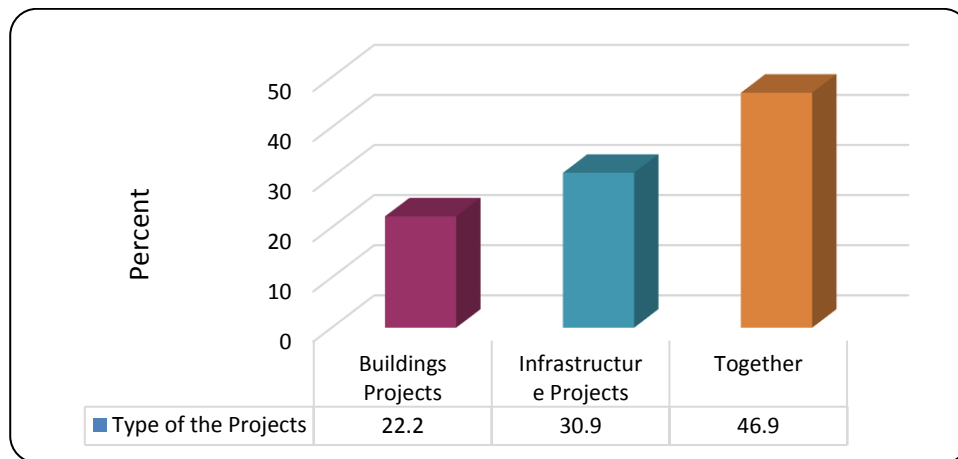


Fig. 1. The type of the projects.

Figure 2 provides the percentages of CAD users where non-use percentage is 19.8%, the use of the 2D only equal 46.9%, the use of 3D only equal 1.2%, the use of 2D and 3D together equal 32.1%.

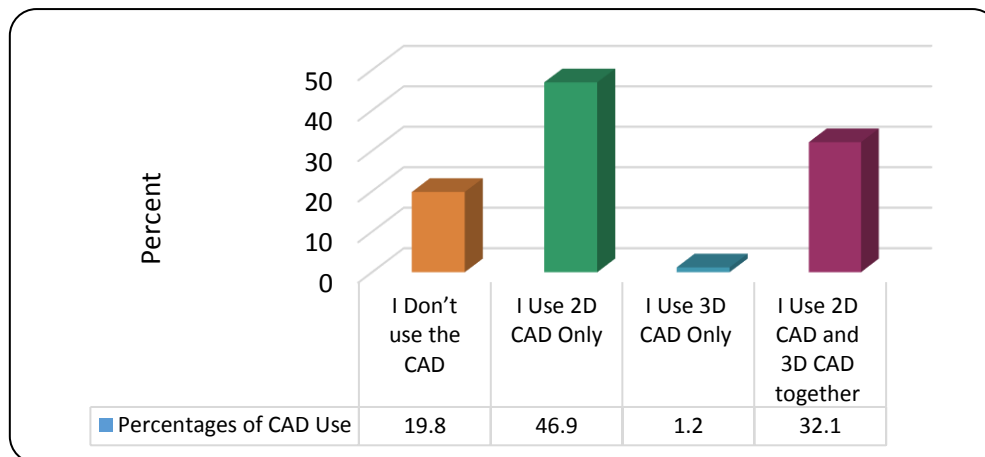


Fig. 2. The percentages of CAD use.

The results give the impression that a relatively small proportion is far from computer use and specifically from CAD used. This may be a positive point in terms of facilitating the application of the BIM because the majority has experience and pre-processing with the computer. On the other hand, the higher percentage of users are use 2D CAD, which may be hindered in their transformation from 2D drawing style in CAD to modeling (not drawing) with multiple dimensions in BIM.

When respondents were asked about the software they used in their engineering field, the answers were as shown in Fig. 3.

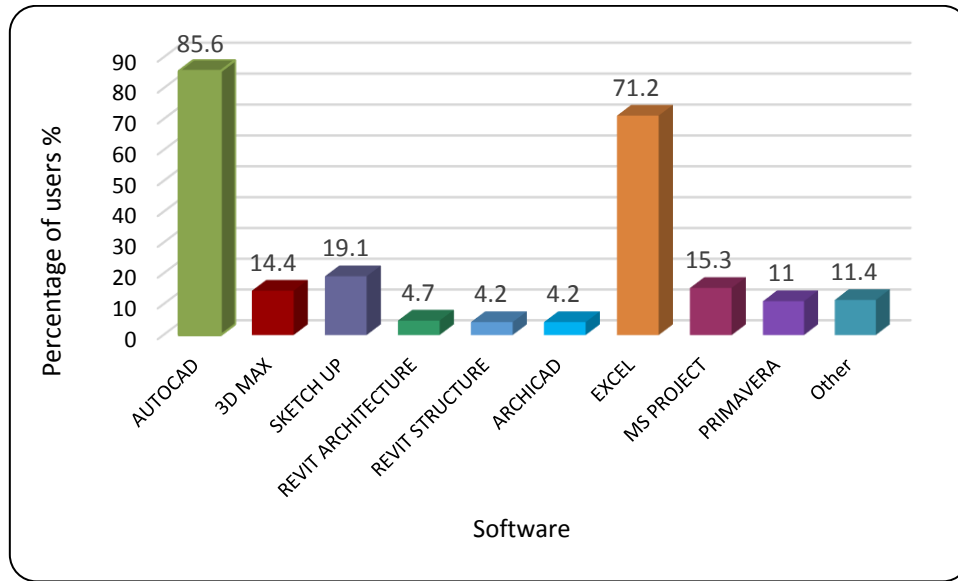


Fig. 3. Software usage percentages.

The documentation system was used to save the documents and all the details of the project were asked from the respondents and the answer is shown in Fig. 4. The highest percentage towards both hard and electronic documentation (65.3%). The percentage of hard documentation was (25.2%) and the electronic documentation was (9.5%).

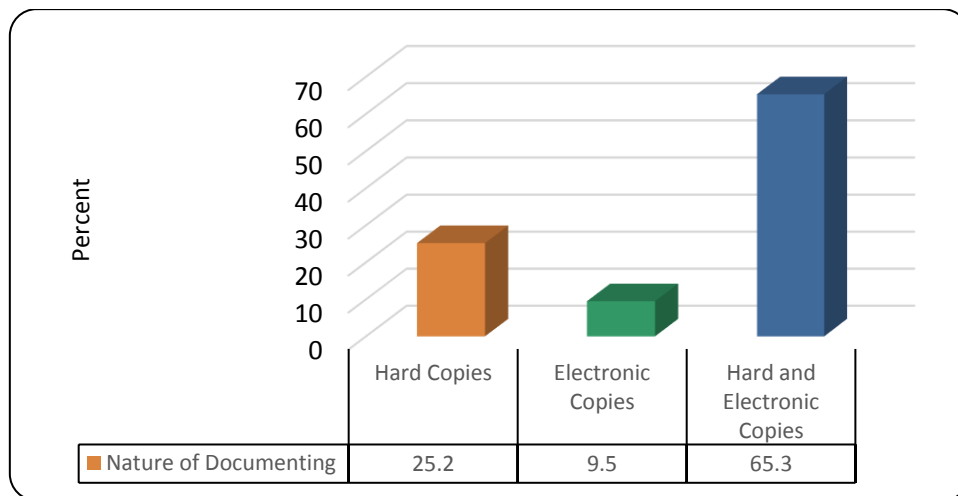


Fig. 4. The nature of documenting project documents.

The results showed that the most common method of documenting project data (both electronic and paper copies together) is limited to storage only. There is really lack of use modern documentation systems that facilitate modification, sharing, storage and take advantages of them in the project during its lifecycle or utilization them in similar future projects.

When respondents were asked whether or not they had heard about Building Information Modeling (BIM), 21.4% of them answered “yes” and explained how they knew it, and 78.6% of them answered that they did not know it as shown in Fig. 5.

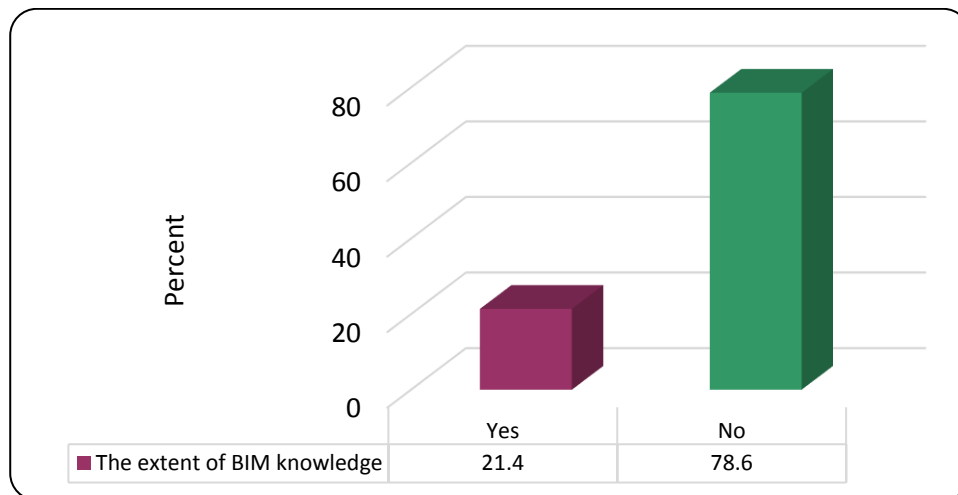


Fig. 5. Respondents answer about their knowledge of BIM.

In this result, it is clear that the level of BIM knowledge of specialists working in the Iraqi construction sector is very weak.

People who had already had knowledge of BIM and answered 0.9% of them worked in companies using BIM (a very small percentage due to the scarcity of BIM in public or private companies and firms), 32.7% knew the BIM by reading research, which is the highest percentage due to the availability of many sources related to the subject, 17.8% are trained to use BIM software with their individual skills, 15.9% Learn about BIM through meetings and seminars and 22.4% heard about the BIM in other ways.

When respondents were asked whether the company or firm in which they worked was using the BIM, 2.7% answered “yes” and 97.3% answered “No” as shown in Fig. 6.

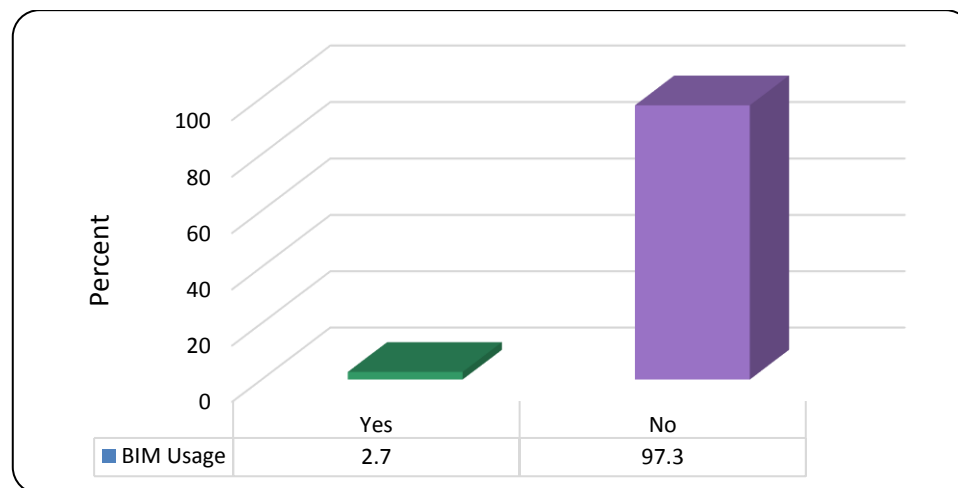


Fig. 6. Respondents answer about BIM usage in place of their work.

The results showed that the use of BIM in the projects is almost non-existent. This logical result is probably due to the ignorance of the benefits of BIM in the public sector on the one hand and the stagnation experienced by the private sector and its inability to apply modern technology.

To give an assessment of the current level of knowledge in BIM, respondents were asked about their description of the level of knowledge in the construction sector and the answer was shown in Fig. 7.

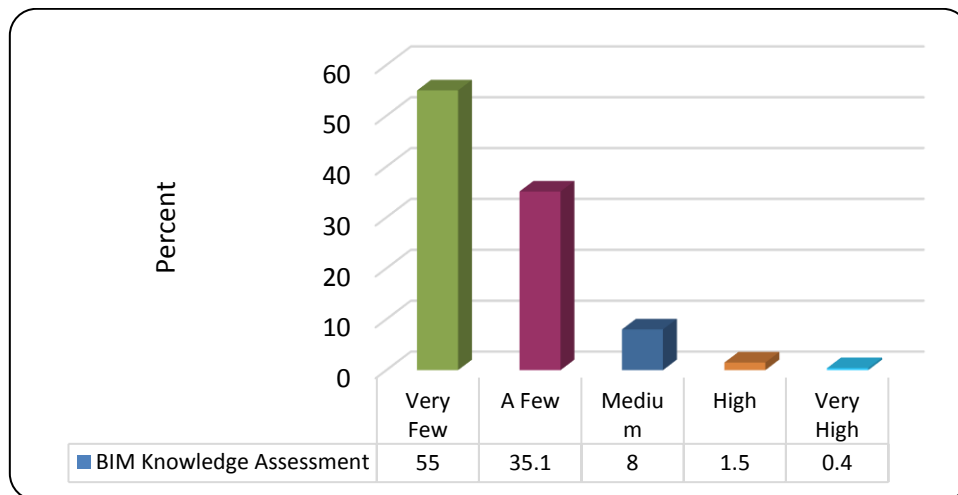


Fig. 7. Assessment of BIM knowledge level.

It is noticeable that by assessing the view of each respondent of general knowledge of BIM is was very weak according to the majority views.

Finally, respondents were asked about their expectations of implementing the BIM in Iraq over the next 20 years the answer was shown in Fig. 8.

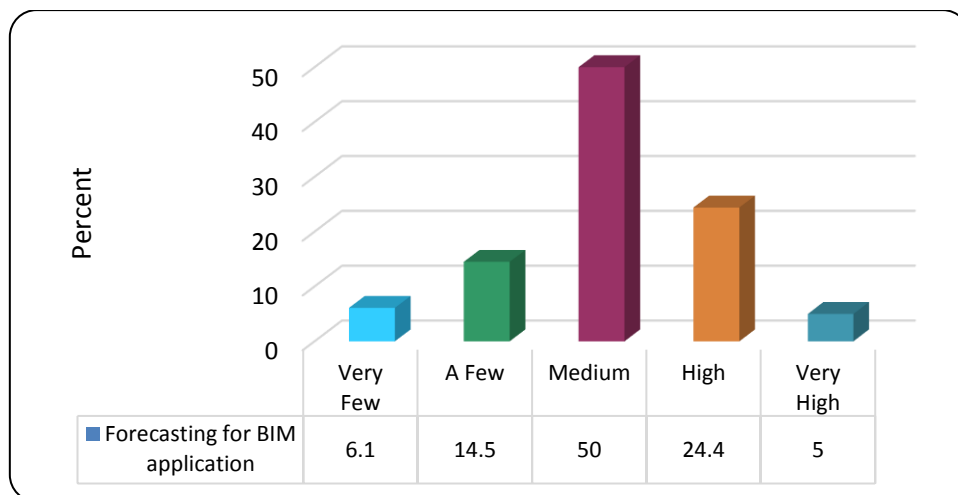


Fig. 8. BIM adoption projections over the next 20 years.

The results showed that the expectations about the application of BIM in Iraq are not very optimistic and not very pessimistic, but between them.

8.3. RII For BIM Potential Barriers

A value of RII for each item was calculated to obtain the rank of the single item within the rest of the items Table 6 shows the mean and standard deviation values for items and the resulting final ranks for each item.

Table 6. Rank of BIM potential barriers depending on RII, Mean, SD.

| No. | BIM Adoption Barriers | Mean | SD | RII | Rank |
|------|---|------|-------|--------|------|
| BA1 | The owner did not request the use of BIM therefore, there is no motivation to think about its adoption at work | 3.40 | 1.201 | 68.168 | 13 |
| BA2 | The cost of BIM software and the cost of its updates | 3.55 | 1.026 | 70.687 | 8 |
| BA3 | The cost of the hardware required with special specifications for the operation of BIM software | 3.21 | .994 | 64.656 | 20 |
| BA4 | The cost of training for BIM software | 3.37 | 1.061 | 67.557 | 14 |
| BA5 | The cost of recruitment BIM specialists and additional staff | 3.53 | .966 | 70.916 | 7 |
| BA6 | Time to apply BIM and its negative impact on current productivity | 3.02 | 1.024 | 60.916 | 22 |
| BA7 | The investment is not clear from the BIM application | 3.02 | 0.973 | 60.763 | 23 |
| BA8 | Shortage of experts in BIM field | 3.84 | 1.077 | 76.870 | 2 |
| BA9 | Insufficient BIM standards and protocols | 3.48 | 1.047 | 69.847 | 9 |
| BA10 | The belief that existing techniques are adequate, there is no need to apply the BIM | 3.15 | 1.234 | 63.130 | 21 |
| BA11 | Problems related to interoperability between BIM software | 3.28 | 1.131 | 65.954 | 17 |
| BA12 | Weak education and training in universities and government centers | 3.59 | 1.197 | 72.061 | 5 |
| BA13 | Weak government efforts to implement BIM | 3.91 | 1.158 | 78.321 | 1 |
| BA14 | The need to manage sophisticated data with the level of evolution of the model | 3.34 | 1.115 | 65.878 | 18 |
| BA15 | Weak cooperation between different disciplines | 3.55 | 1.073 | 71.298 | 6 |
| BA16 | Exposure to the risks associated with intellectual property model and the cost of copyright and publishing | 3.23 | 1.071 | 64.962 | 19 |
| BA17 | The need for amendment in design regulations and regulations | 3.32 | 1.006 | 66.565 | 15 |
| BA18 | The need to formulate BIM contracts | 3.40 | 1.035 | 68.321 | 12 |
| BA19 | Weak knowledge of BIM benefits | 3.74 | 1.100 | 74.809 | 3 |
| BA20 | Weak skill among engineers and a difficulty in learning BIM software | 3.32 | 1.173 | 66.489 | 16 |
| BA21 | Lack of qualified cadres and experts to train BIM software | 3.44 | 1.192 | 68.702 | 11 |
| BA22 | The need to uninterrupted power and a strong Internet can accommodate the vast amount of information | 3.46 | 1.095 | 69.313 | 10 |
| BA23 | The strong resistance to change, especially the large ages, and the engineers stuck to the software just familiar to them | 3.63 | 1.149 | 72.672 | 4 |

The results showed that “Weak government efforts to implement BIM” is the highest potential barrier for BIM application according to the point of view of specialists with (RII=78.321, mean=3.91, SD=1.158). The Iraqi government has not shown a distinctive role in the adoption and dissemination of modern technologies in the field of the Iraqi construction sector. It is logical that the most important barriers that were nominated by the respondents are the weakness of the government efforts to implement the BIM, On the other hand, this result shows agreement with many researchers who have studied the subject of BIM [36-40].

The potential BIM barrier which was in the second rank is “Shortage of experts in BIM field” with (RII=76.870, mean=3.84, SD=1.077). This result is consistent with what Ali [41] mentioned. Other researchers from different countries indicates that shortage of experts in BIM field is one of the most important BIM barriers [37, 42-50].

The third potential barrier of BIM is “Weak knowledge of BIM benefits” with (RII=74.809, mean=3.74, SD=1.100). This is due to the lack of self-development of most of those working within the Iraqi construction sector. This results also agrees with researchers from other countries [19, 40, 42, 43, 49, 51-56].

The fourth potential barrier of BIM according to the point of view of the specialists is “The strong resistance to change, especially the large ages, and the engineers stuck to the software just familiar to them” (RII=72.672, mean=3.63, SD=1.149) This finding is not strange, as there has been consensus among many researchers that it is an important BIM barrier [39, 48, 57-63].

The fifth rank of BIM potential barriers was “Weak education in the universities or government training centers” with (RII=72.061, mean=3.59, SD=1.197). Where the Iraqi universities suffer in general from weakness in keeping pace with modern technologies, including the BIM. On the other hand, the weakness of the training provided by government centers is very weak and this was mentioned out by many researchers as one of the most important barriers that hinder the application of BIM [1, 36, 40, 47, 49, 59, 62, 64, 65].

The two lowest-ranking benefits are “Time to apply BIM and its negative impact on current productivity” and “The investment is not clear from the BIM application” according to the point of view of specialists. On the other hand, the top five potential BIM barriers seem to be logical and consistent with the problems of Iraq's construction projects.

9. Conclusions and Recommendations

According to Iraqi professionals views the first barrier facing the use of BIM in Iraqi construction projects is the weakness of the government's efforts and the lack of its interest in its implementation. Lack of experts in the field of BIM is the second barrier facing the use of BIM is the construction projects of Iraq. Poor knowledge about the benefits of BIM, resistance to change, poor training and education all these are important barriers facing BIM use.

In order to increase the level of knowledge in BIM, it is recommended that many seminars and conferences be held which in consultation with the experts in the field of construction projects, on the other hand, to raise the skill level of engineers it is recommended to provide training programs in government centers and institutions. Building and supporting academic projects as well as encouraging researchers in the field of BIM which will facilitate the transfer of expertise and information from the world. The government must play a vital role by providing the main guidelines to institutions in its transition toward BIM. The government can build a generation that has knowledge of BIM by imposing a BIM curriculum in university education. The change towards the BIM should not be sudden and rapid as the presence of resistance to change must be addressed in several points, including providing training and application to small cases at first, this would break the psychological barriers and accept BIM.

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Appendix 1: (Questionnaire—English version)

Part I: Personal information (information about the person completing the questionnaire)

| | |
|--|---|
| Name (Optional): | |
| Work sector: | <input type="checkbox"/> Public <input type="checkbox"/> Private <input type="checkbox"/> Public and Private together |
| Gender: | <input type="checkbox"/> Male <input type="checkbox"/> Female |
| Age: | <input type="checkbox"/> 20-30 years <input type="checkbox"/> 31-40 years <input type="checkbox"/> 41-50 years <input type="checkbox"/> More than 51 |
| Educational level: <input type="checkbox"/> Diploma <input type="checkbox"/> Bachelor <input type="checkbox"/> Master <input type="checkbox"/> Ph.D. <input type="checkbox"/> Other (specify please) | specialization: <input type="checkbox"/> Architect <input type="checkbox"/> Civil Engineer <input type="checkbox"/> Electrical Engineer <input type="checkbox"/> Mechanical engineer <input type="checkbox"/> Other (please specify) |
| Belong to any group: <input type="checkbox"/> Designer <input type="checkbox"/> Consultant <input type="checkbox"/> Project Manager <input type="checkbox"/> Site engineer <input type="checkbox"/> Contractor <input type="checkbox"/> Other (specify Please) | Practical experience: <input type="checkbox"/> Less than two years <input type="checkbox"/> From 2 to 5 years <input type="checkbox"/> From 5 to 10 years <input type="checkbox"/> More than 10 years |

Part II: Current Practices and Knowledge of Modeling Building Information

| | |
|---|---|
| What is your work sector? <input type="checkbox"/> buildings projects <input type="checkbox"/> infrastructure projects <input type="checkbox"/> Building and Infrastructure together | What is your usage of the CAD? <input type="checkbox"/> not used the CAD <input type="checkbox"/> used the 2D only <input type="checkbox"/> used the only 3D <input type="checkbox"/> used the 2D and 3D together |
| Any of the following you use in your business software engineering? (Select one or more) | |
| <input type="checkbox"/> AUTODESK AUTOCAD | <input type="checkbox"/> 3D MAX |
| <input type="checkbox"/> SKETCH UP | <input type="checkbox"/> REVIT ARCHITECTURE |
| <input type="checkbox"/> REVIT STRUCTURAL | <input type="checkbox"/> ARCHICAD |
| <input type="checkbox"/> EXCEL | <input type="checkbox"/> MS PROJECT |
| <input type="checkbox"/> PRIMAVERA | <input type="checkbox"/> Other (specify please) |

What is the nature of the documentation system, storage and exchange of data in the project?

- ☐ hard copies
☐ electronic versions
☐ hard copy and electronic

Have you ever heard about Building Information Modeling (BIM) and the promise of applications and solutions?

- ☐ Yes
☐ No

If yes, please select a paragraph or more of the following paragraphs:

- ☐ worked in companies using the BIM programs
- ☐ read researches related to BIM
- ☐ I am training on the use of the BIM programs individually
- ☐ participated in conferences or meetings related to BIM
- ☐ part dealt with in my university
- ☐ Other (specify Please)

Does BIM use in one of your organization's projects?

- ☐ Yes
- ☐ No

| | |
|--|---|
| <p>How would you describe the current level of knowledge of BIM in the Architecture, Engineering (AEC) and construction in Iraq?</p> <ul style="list-style-type: none"> <input type="checkbox"/> Very few <input type="checkbox"/> A few <input type="checkbox"/> Medium <input type="checkbox"/> High <input type="checkbox"/> Very high | <p>What percentage do you think that the use of BIM in Iraq would be mandatory in the 20 coming years as is the case for other countries?</p> <ul style="list-style-type: none"> <input type="checkbox"/> Very few <input type="checkbox"/> A few <input type="checkbox"/> Medium <input type="checkbox"/> High <input type="checkbox"/> Very high |
|--|---|

Part III: Potential barriers to BIM implementation

As you know the current situation of the Iraqi construction sector, what is your assessment of the following barriers facing the application of building information modeling (BIM)?
Please tick (✓) under the column you see fit.

| Number | Item | Very Weak | Weak | Moderate | Strong | Very Strong |
|--------|---|-----------|------|----------|--------|-------------|
| 1 | The owner did not request the use of BIM therefore, there is no motivation to think about its adoption at work | | | | | |
| 2 | The cost of BIM software and the cost of its updates | | | | | |
| 3 | The cost of the hardware required with special specifications for the operation of BIM software | | | | | |
| 4 | The cost of training for BIM software | | | | | |
| 5 | The cost of recruitment BIM specialists and additional staff | | | | | |
| 6 | Time to apply BIM and its negative impact on current productivity | | | | | |
| 7 | The investment is not clear from the BIM application | | | | | |
| 8 | Shortage of experts in BIM field | | | | | |
| 9 | Insufficient BIM standards and protocols | | | | | |
| 10 | The belief that existing techniques are adequate, there is no need to apply the BIM | | | | | |
| 11 | Problems related to interoperability between BIM software | | | | | |
| 12 | Weak education and training in universities and government centers | | | | | |
| 13 | Weak government efforts to implement BIM | | | | | |
| 14 | The need to manage sophisticated data with the level of evolution of the model | | | | | |
| 15 | Weak cooperation between different disciplines | | | | | |
| 16 | Exposure to the risks associated with intellectual property model and the cost of copyright and publishing | | | | | |
| 17 | The need for amendment in design regulations and regulations | | | | | |
| 18 | The need to formulate BIM contracts | | | | | |
| 19 | Weak knowledge of BIM benefits | | | | | |
| 20 | Weak skill among engineers and a difficulty in learning BIM software | | | | | |
| 21 | Lack of qualified cadres and experts to train BIM software | | | | | |
| 22 | The need to uninterrupted power and a strong Internet can accommodate the vast amount of information | | | | | |
| 23 | The strong resistance to change, especially the large ages, and the engineers stuck to the software just familiar to them | | | | | |

Appendix 2:

Table 1. Top BIM barriers according to previous researchers.

| Country Reference | Top barriers | Country and Reference | Top barriers |
|--------------------------|---|-------------------------|---|
| UK [66] | <ul style="list-style-type: none"> Waste time and human resource Cost copyright and training Unsuitable for the small projects Current technology is enough People refuse to learn | USA [65] | <ul style="list-style-type: none"> staff related issues (training/hiring / replacing) as well as system customization ownership of information spirit of collaboration and risk associated with sharing information |
| UK [57] | <ul style="list-style-type: none"> fragmented project teams The strong resistance to change lack of a well-trained workforce | UK [1] | <ul style="list-style-type: none"> Firms are not familiar enough with BIM use Firms do not have enough opportunity for BIM implementation Reluctance to initiate new workflows, or train staff |
| USA [67] | <ul style="list-style-type: none"> Owners need to be instructed to know about BIM Huge files are generated by applying BIM limitation in hardware capacities | MALAYSIA [59] | <ul style="list-style-type: none"> difficulty in learning the BIM software lack of legal backing from authorities Lack of skilled BIM Software operators Cost of software |
| AUSTRALIA [51] | <ul style="list-style-type: none"> Weak knowledge of BIM Education & training costs Initial Setup costs Changing the ways firms do business Finding trained staff | USA [22] | <ul style="list-style-type: none"> Learning curve and lack of skilled personnel Cost/lack of company investment Lack of collaborative work processes and modeling standards |
| SWEDEN [68] | <ul style="list-style-type: none"> Personal opinions towards BIM The strong resistance to change it hard to find stakeholders that have the required competence to participate in BIM projects | ICELAND [69] | <ul style="list-style-type: none"> BIM is too expensive Other project team members are not requiring BIM Existing CAD system fulfills our need to design and draft BIM does not reduce time used on drafting compared with current drawing approach |
| UK [42] | <ul style="list-style-type: none"> Lack of tangible benefits for all parties involved or the understanding of the business value of BIM Lack of experience within the workforce Time and Cost | USA [70] | <ul style="list-style-type: none"> Cost of software Required hardware upgrades too expensive There is no sufficient time to evaluate it Believe current methods are better |

| | | | |
|----------------------------|---|--------------------------------------|--|
| | <ul style="list-style-type: none"> • The strong resistance to change | | |
| UK [44] | <ul style="list-style-type: none"> • Lack of expertise • Lack of standardized tools and protocol • Lack of collaboration • Initial Setup costs | IRELAND [36] | <ul style="list-style-type: none"> • Lack of Training / Education • The owner did not request the use of BIM • Lack of Government Lead/Direction • Lack of Standards |
| UK [43] | <ul style="list-style-type: none"> • lack of personal knowledge and experience • Weak knowledge of BIM | AUSTRALIA [60] | <ul style="list-style-type: none"> • Difficulty in finding skilled people to work with BIM • High cost to implement BIM • Lack of training |
| IRAQ [71] | <ul style="list-style-type: none"> • Weak knowledge of BIM • The weakness of personal skills available • Lack of training • Cost of training | UK [47] | <ul style="list-style-type: none"> • The owner did not request the use of BIM • Small projects do not care about using the BIM • Initial Setup costs • The strong resistance to change |
| UK [19] | <ul style="list-style-type: none"> • training staff on new process/workflows • understanding BIM enough to implement | NIGERIA [72] | <ul style="list-style-type: none"> • The resistance to change (Social hand y Habitual) • The need for BIM contracts • Cost of training |
| QATAR [54] | <ul style="list-style-type: none"> • Shortage of experts • The need for special contracts • The strong resistance to change • Weak competition | MALAYSIA [53] | <ul style="list-style-type: none"> • Weak knowledge of BIM • The owner did not request the use of BIM • The strong resistance to change • BIM is not h required by others team members |
| NEW ZEALAND [61] | <ul style="list-style-type: none"> • Problems related to interoperability • Initial Setup costs • Insufficient BIM standards | UK [62] | <ul style="list-style-type: none"> • Initial Setup costs • Time of training • Problems related to interoperability • Change in work methodologies |
| UK [37] | <ul style="list-style-type: none"> • Shortage of experts • Lack of training • The owner did not request the use of BIM • Initial Setup costs | AUSTRALIA & CHINA [38] | <ul style="list-style-type: none"> • Insufficient BIM standards • Cost of software • Time of training |
| INDIA [39] | <ul style="list-style-type: none"> • Weak competition • Cost of software • The owner requests the use of BIM only at certain stages • Shortage of experts | IRAQ [41] | <ul style="list-style-type: none"> • Lack of clarity of responsibilities for data content • The role of BIM director needs to be assigned • The philosophy of BIM requires the restructuring of work methodologies within companies |

| | | | |
|--------------------------|--|-------------------------------|--|
| | | | <ul style="list-style-type: none"> • Insufficient BIM standards • Weak knowledge of BIM |
| GHANA [55] | <ul style="list-style-type: none"> • Weak knowledge in use BIM • Problems related to interoperability • Initial Setup costs • Ownership of the model | UK & CHINA [40] | <ul style="list-style-type: none"> • Data management issues • The strong resistance to change • Weak knowledge of BIM • Cost of software • Lack of training |
| UK [49] | <ul style="list-style-type: none"> • Weak knowledge of companies about concept of BIM • Initial Setup costs • Weakness in cooperation | RUSSIA [56] | <ul style="list-style-type: none"> • Lack of qualified cadres for training • The strong resistance to change • The need for amendment in design regulations and regulations |
| AUSTRALIA [73] | <ul style="list-style-type: none"> • Lack of knowledge and experience of sub-contractors in BIM • Lack of knowledge of owners in BIM • Initial Setup costs • Sub-contractors do not care about using the BIM • The cost of training | AUSTRALIA [74] | <ul style="list-style-type: none"> • The owner did not request the use of BIM • Initial Setup costs • Small projects do not care about using the BIM • Insufficient BIM standards and protocols • The strong resistance to change |
| KUWAIT [75] | <ul style="list-style-type: none"> • Lack of training • Lack of Engineers' skill • Weak knowledge of BIM | JORDAN [76] | <ul style="list-style-type: none"> • Weak government efforts • Insufficient BIM standards and protocols • Weak knowledge of BIM • The strong resistance to change |