Execution Quality of Construction Projects with Building Information Modeling BIM- technology

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Abstract: The poor performance of the construction of buildings has been the subject of discussion over the past century, and hence, substantial initiatives have been taken to address the poor management. The article aims to evaluate the reality of execution quality in engineering projects in Iraq in the public and private sectors. For this purpose, a questionnaire was designed commensurate with this purpose , and the questionnaire was distributed to engineers and technicians in the public and private sectors. For the data analysis and computation of percentages, mean, and standard deviation for each response, statistical software (SPSS-V28) was utilized. As a consequence of the answer analysis, the results determined that there is a deficiency in the execution quality, project management's obligations to assure and regulate quality, and non-compliance. Also results shown there is a need to use modern and advanced Building Information Modeling programs to ensure and control quality that is characterized by accuracy and clarity, as well as to provide an integrated system to which project parties can return when needed .The current software is used to control execution quality.

Keywords: construction project, building Information, modeling, quality, quality control, quality assurance.

Introduction

According to the report published in 2017, almost 70% of the construction projects globally have budget overruns, and around 61% have time overruns. The report outlined that this is due to several reasons including but not limited to the lack of investment in skills development and innovation, poor project management, inadequate personnel skills, and lack of efficiency in project management [1].

the lack of performance within the construction industry in his report in 1998. The report concluded that the industry is suffering from major five problems which need to be addressed: a) Construction Industry clients not satisfied (Cost, Time and Quality); b) The delivery team not satisfied; c) Industry’s Bad Reputation; d) Low profitability; e) Lack of Innovation and Development [2] .

More recent research indicates that the ideals highlighted by [3] as a way of enhancing success in the construction industry are yet to be satisfied.

Projects mainly comprise three main stages: planning, design and construction. Some of the common problems included the time-consuming nature of the 2D architectural scale model, difficulties in assessing concept design in relation to the building surrounding environment, low information integration and failure to provide adequate information for assessment of impact building aspects such as cost [4].

Such a change in project management had a very large impact on the evolution of the construction industry. As construction projects' size and complexity kept increasing, the role of construction manager gradually evolved improvements to the overall process, and today there are various approaches of project delivery methods [5].

It can also be noted that the need for better coordination of construction projects was evident from as early as 1980 when clients of construction projects increasingly lamented of poor performance in the field. The clients demanded better quality, reduced cost and timely delivery of construction projects in both the private and public sectors [6].

Defining and formalizing the required useful building construction information before the implementation of an asset is the key to the effective management of this vast quantity of information, and this is critical to the success of facility operations [7].

Also, designers and constructors seldom know what information is needed for the construction management. Projects mainly comprise three main stages: planning, design and construction [8].

Building construction management depend on the accuracy and accessibility of data created in the design and construction phases and updated throughout the implementation phase. The impact of client representative and their influence on the project's performance. He suggested that there it is recommended

to have a client representative mainly for building a relationship between stakeholders which has the greatest impact on project success [9].

there are many advantages to using a project management consultant. These advantages include: having the brief prepared by a skilled professional; having a professional manage any confrontations; releasing the architect from management; an independent and sole point of contact for the client. Most of these advantages and disadvantages have been reported by many other researchers in various forms [10].

Although most of over mentioned advantages are consider from client perspective; there is a major advantage for the benefit of the architects which is releasing them from the management; which could be argued as management is not their best skill. Arguments have also been raised about evaluating the performance of construction projects management and how positively or negatively they influence on the project [11].

Data Collection Methods

The questions were constructed in accordance with the causes or other impacts that might result in projects of low quality. It is a recognized scientific methodology built on generating ideas and problem-solving approaches to achieve judgments that the author cannot reach alone. This study is addressed at experts working in the construction industry from many disciplines, including both the public and private sectors, in order to collect the data required for the objectives set out in the study to support the testing of the survey model and its hypotheses.

Design of Questionnaire

the questionnaire was divided into four components and was created . In order to encourage a greater response rate, the questionnaire was connected with a note about the confidentiality of the responses provided by the respondents. Each part of the questionnaire will be explained . Figure 1.

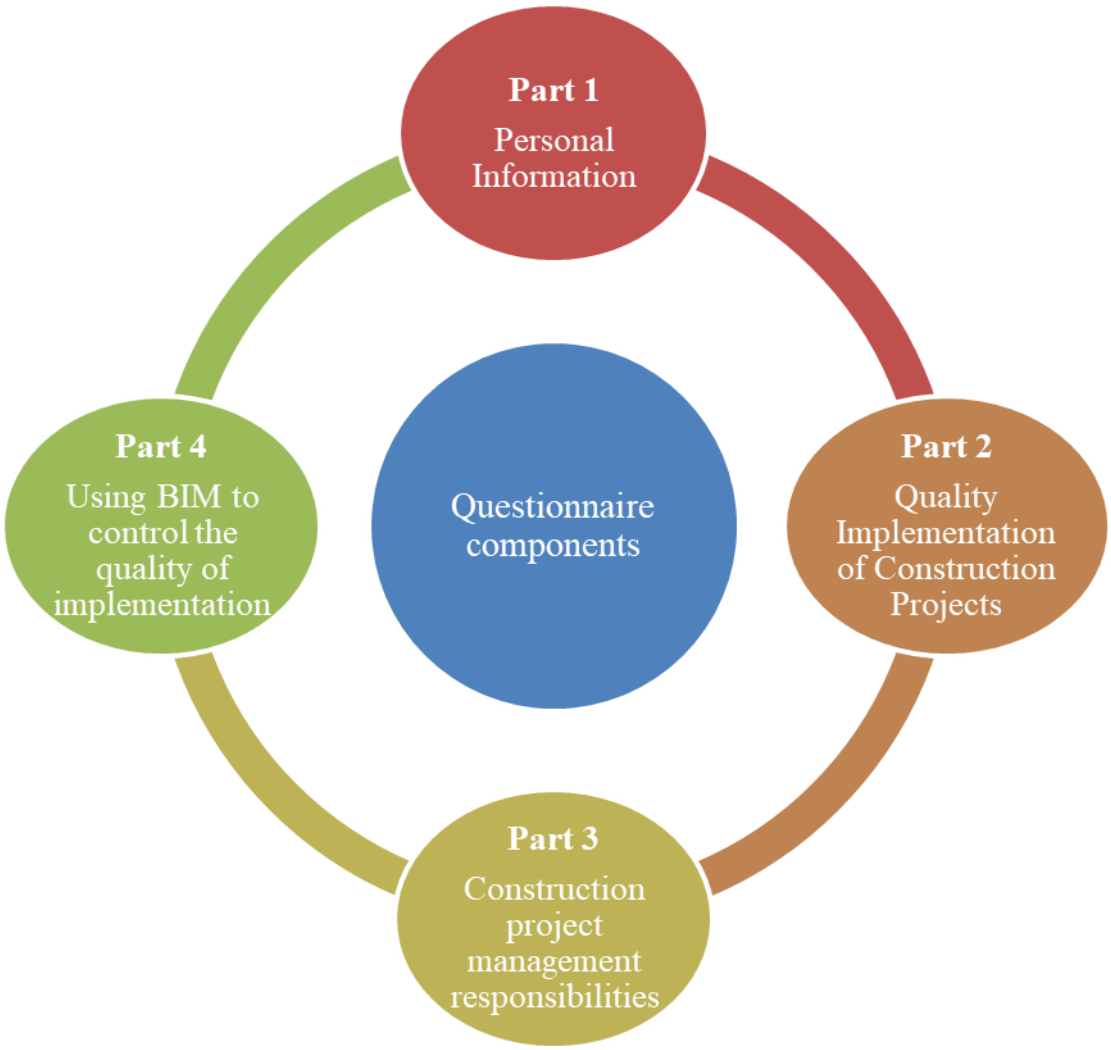

Figure .1: Components of the questionnaire (Author).

The second and third sections of the questionnaire use a five-point Likert scale. The weighing scale is (1: not available, 2: rarely, 3: sometimes, 4: often, and 5: Always). Each respondent was asked to rate each question on a scale of 1 to 5 based on his perceptions of the global construction sector's climate (Likert, 1932). While the last section includes a (yes/no) question.

Arbitration of the Questionnaire

The questionnaire arbitration is characterized as an essential sort of validity provided by experts as a judgment on the instrument's ability to measure. As a consequence, the arbitration was held to test the validity of the questionnaire by

presenting it to three groups of experts and asking them to voice their thoughts and comments on it.

The first group was asked to assess the questionnaire questions in terms of their relevance to the study framework and if they reflected the research idea. The second group comprises statistical professionals who determine if the questionnaire was properly designed and can be utilized to conduct statistical tests. Finally, the third group was polled on their thoughts on the questionnaire in English, and the credentials of the experts are listed in Table 1.

Table 1: Arbitrators' information.

Group	Expert	Educational Qualification	Work Place	Country
Content	C1	Ph.D. in Construction Management	Liverpool John Moores University	England
	C2	Ph.D. in Road and Airport Engineering	University of Technology	Iraq
	C3	Ph.D. in Architectural Engineering	University of Babylon	Iraq
	C4	M.Sc. in Construction Management	Liverpool John Moores University	England
Statistic	S1	Ph.D. in Statistics	University of Baghdad	Iraq
Language	L1	Ph. D.. English Language	Imperial College London	England

Statistical Reliability

In any investigation, the use of an appropriate measuring instrument as one of the fundamental criteria includes access to satisfactory data, listed that one of the author s' main goals is to design and distinguish his research method by three main qualities (be meaningful, be accurate, be efficient. Therefore, reliability test was conducted on the data obtained from the case study using (SPSS V.28).

Alpha (Cronbach) Model

One of the most common methods of calculating the reliability. The high reliable value of alpha Cronbach from 0 to 1 and the closest to 1 shows one of the most popular methods for measuring reliability and value. Table 2 below represents a classification for the degree of reliability according to the value of the alpha-Cronbach coefficient.

Table 2: Reliability cutoff values (Yockey, 2016).

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

The findings were found in the good limits of the Alpha Cronbach system for the questionnaire, which supports the reliability of the questionnaire. Table 3 shows the values for those portions of alpha Cronbach.

Table 3: Value of alpha Cronbach for questionnaire ’s parts.

Items	**Value of α**	**Degree of reliability**
Quality Implementation Control In Construction Projects	0.832	Good
Construction Project Management Responsibilities	0.844	Good
Use of BIM to Control the Quality of Implementation	0.849	Good

Questionnaire Distribution

About sample size, response rate and the way the author used to distribute the questionnaire, it can be explained as follows:

Sample Size and Response Rate

The author was able to collect (54) forms only from the original (60) distributed forms by using the questionnaire on the sample, therefore the response rate was (54 ÷ 60 =90% percent), which was a high response rate owing to the personal distribution of forms. After verifying the forms, (4) incomplete forms were removed, resulting in a total of (50) forms included in the study.

Sample Description

The characteristics of the questionnaire sample are depicted in the figures below. Figure .2 depicts the percentage of respondents by work sector, with the public sector accounting for 76% and the private sector accounting for 24%.

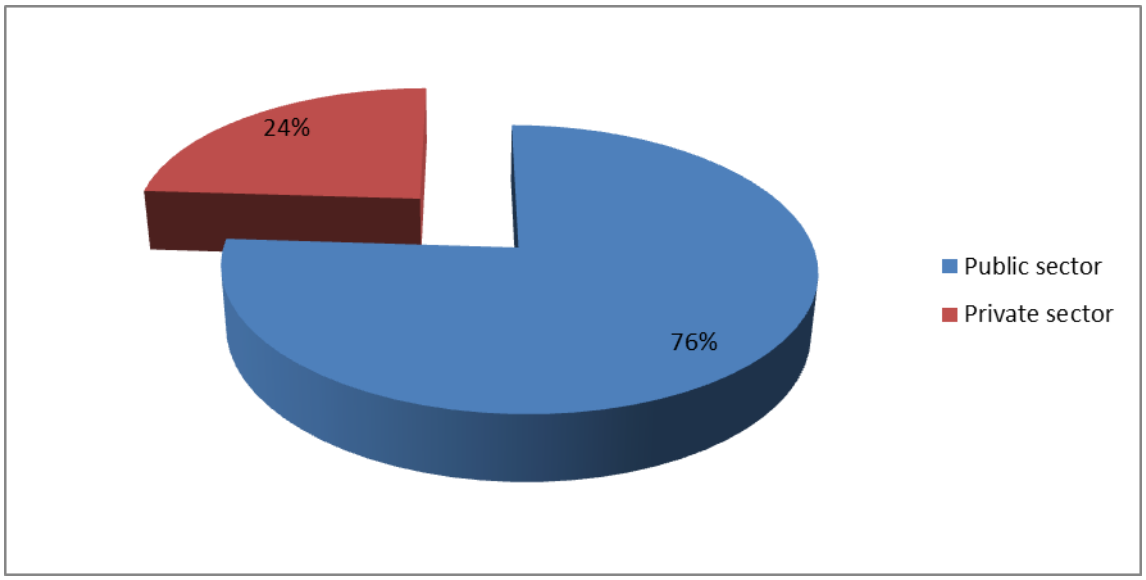

Figure 2: The percentage of respondents according to work sector.

The age proportion of respondents, with a percentage of 25-35 years equaling 20%, 36-45 years equaling 54%, 46-55 years equaling 22%, and more than 55 years equaling 4%.

Figure 3.

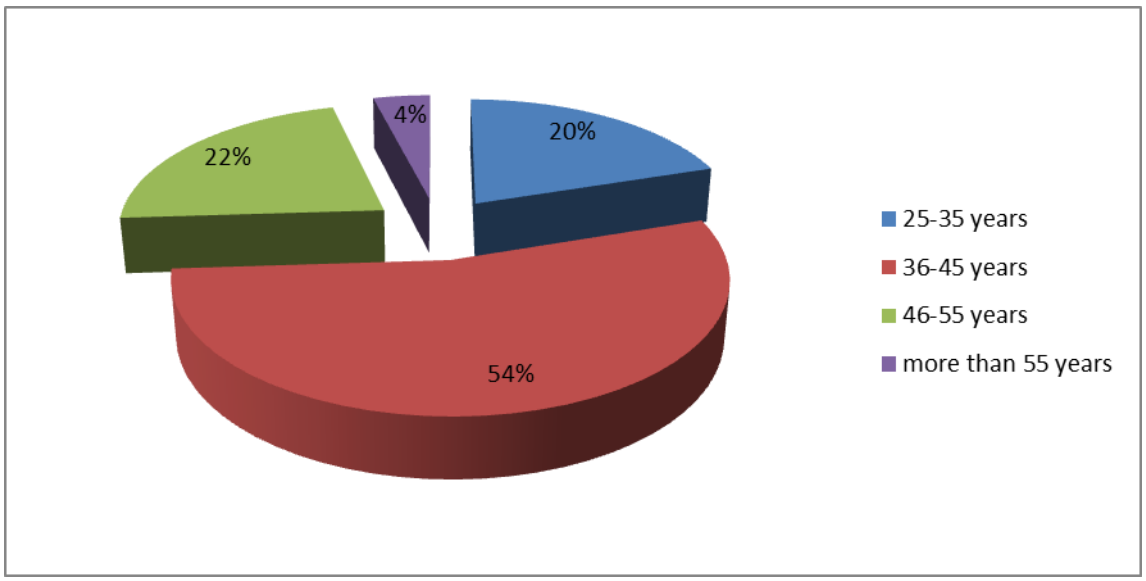

Figure 3: The age proportion of respondents.

The academic qualification of respondents where the percentage of Technical Diploma is (4%), Bachelor (56%), High Diploma (4%), Master (24%), and Ph.D. (12%).

Figure 4.

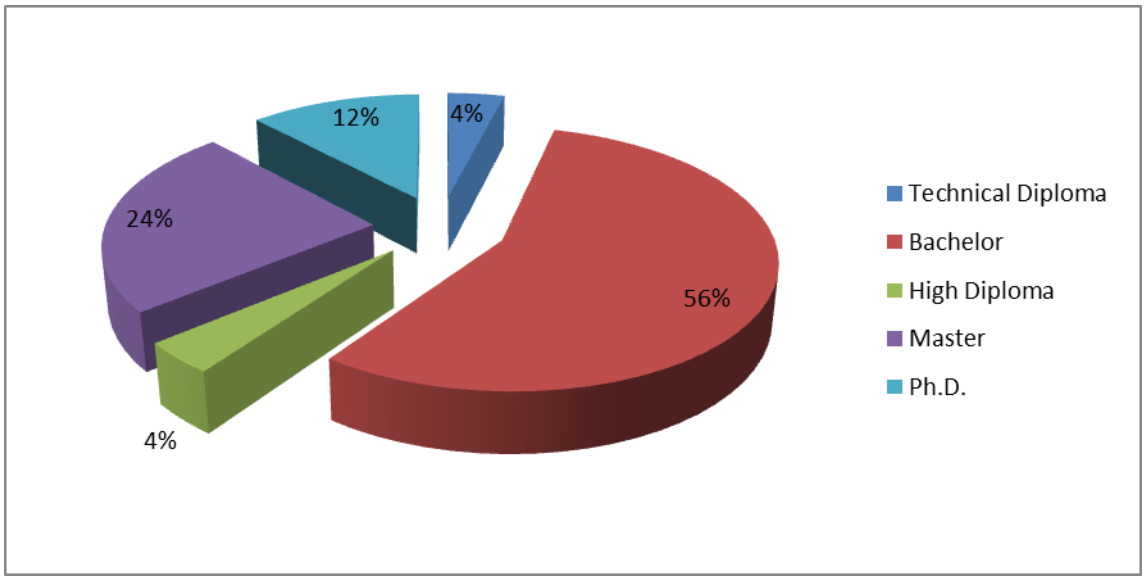

Figure 4: Respondents' educational levels.

Figure 5 illustrates the specialization of respondents where the percentage of Civil Engineer (60%), Mechanical Engineer (20%), Electrical Engineer (12%) and Architect is (8%).

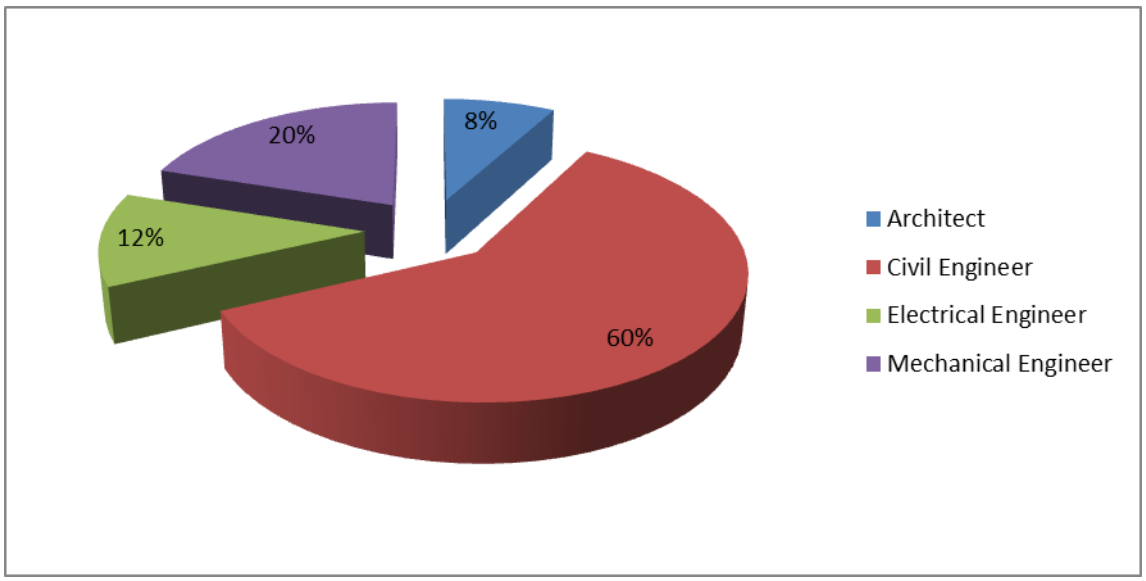

Figure 5: Respondents' specialization.

Figure 6 displays the respondents' group, where the percentage of project managers is (8%), consultants (8%), Department Manager (20%), Division Officer (24%), site engineers (30%), contractors (4%), and Academic (6%).

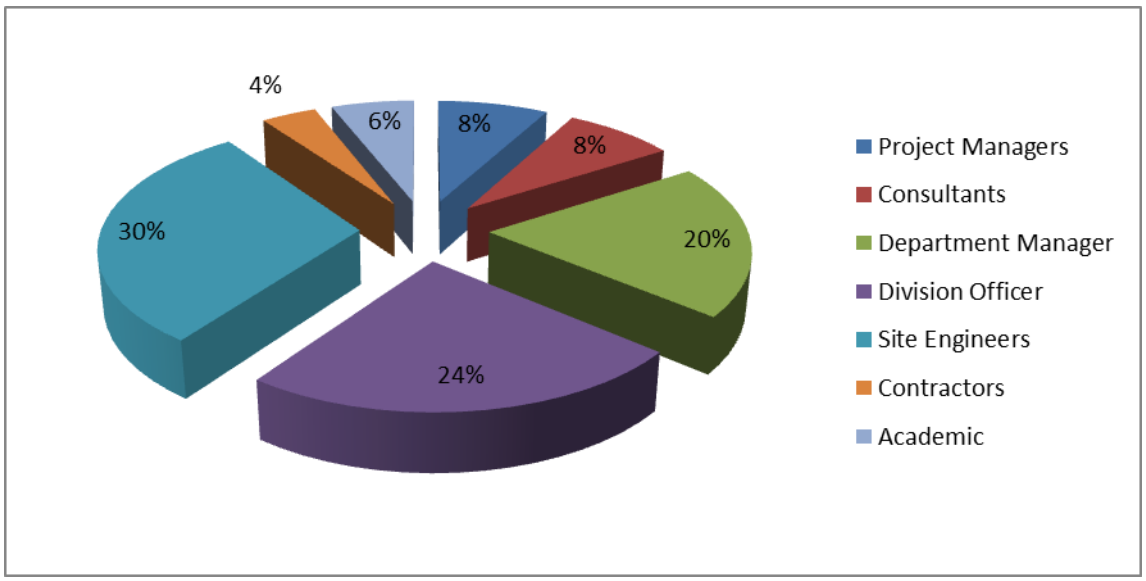

Figure 6: The respondents' group.

Figure 7 evinces the respondents' practical experience. The percentages are as follows: less than 5 years (2%), 5-10 years (16%), 11-15 years (30%), 16-20 years (38%), and more than 20 years (14%).

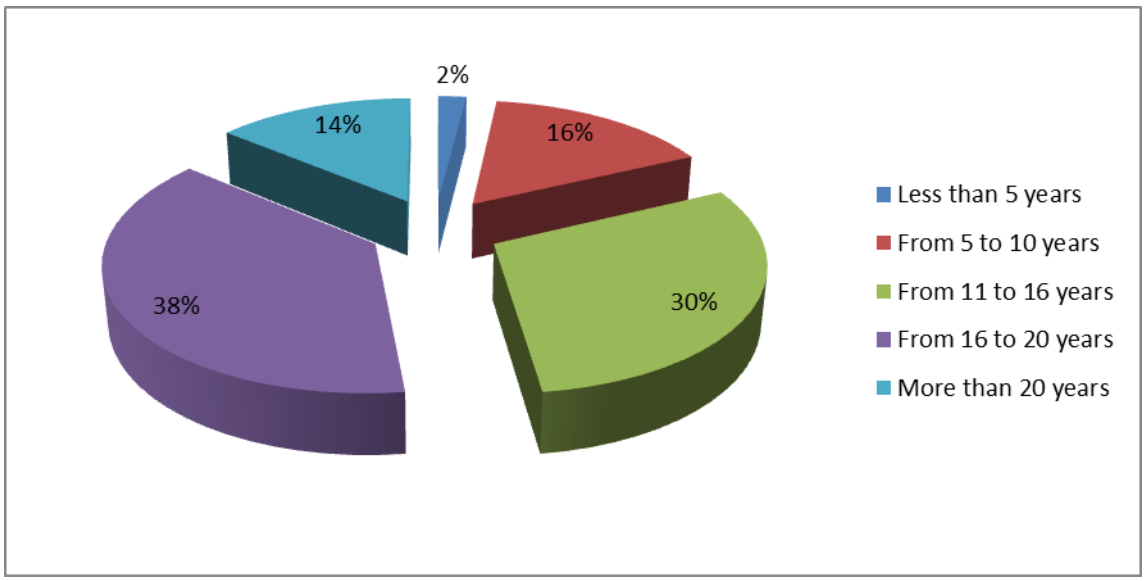

Figure 7: The respondents' practical experience

Statistical Analysis

Questionnaire Distribution Administration

The questionnaire is distributed using the interview process. It is noted that the interview approach has a reasonably high response rate and decreases in contrast to other methods, like the online questionnaires, the likelihood of mistake or insufficient responses. The interview process was twofold. Some governmental organizations provided the author with facilities to conduct one or more seminars to talk about the quality of construction projects and answer the questionnaire after these seminars. Small numbers of other companies did not have facilities or use the second form, namely the direct interview with the interviewee.

Descriptive Statistics

Descriptive statistics are definable as statistical tools for data summarization, data organization, and data simplification (Gravetter, F. J. and Wallnau, 2016). Descriptive statistics that have been used is "Central Tendency Measurement". The core trend of the statistics relates to the notion of representative (average) value that seeks to characterize the distribution of values that is of the best single value (Gravetter, F. J. & Wallnau, 2016).

Results of the Questionnaire

The questionnaire was quantitatively statistically analyzed using the Social Science Package (SPSS) version 28. The data was analyzed in order to assess the quality of the construction projects. This section includes the results of the questionnaire regarding the second, the third, and the fourth part, as shown below:

Part II: Quality Implementation Control in Construction Projects

The second part consisted of (12) questions concerning the things in terms of quality control throughout project execution. Table 4 depicts the analysis of the second part's elements, as well as the arithmetic mean and standard deviation for each paragraph in the part. A five Likert scale was used (always, often, sometimes, rarely, and never (no)).

From the results in Table 4, it can be seen that, “The project partners' interest in the project's cost exceeds the needed quality,” is the highest percentage of response level based on the opinions of experts (mean =4.0, SD=1.03). This high proportion can be linked to construction projects' usual reliance on cost reduction at the expense of project quality, which implies that quality is rarely applied in construction projects throughout the execution stage. The result of question no. (3), "The presence of a quality control information system that is integrated," is based on expert judgments (mean=1.6, SD= 0.86). This result is consistent with the absence of a quality control information system in the Iraqi construction projects.

The result of question no. (8), “The availability of training and courses for current programs to improve the workers' competence and efficiency in the field of quality,” is (always = 1.6 %, mean=1.6, SD= 0.91). The construction projects suffer from a lack of training and courses for modern programs which makes a weakness in the skill and efficiency of workers in the field of quality.

Finally, from the results in Table (3.4) based on expert judgments, the total average is (mean=2.3, SD=0.93). This result is consistent with the Iraqi building

projects suffering from poor quality, implying that quality control is rarely used in construction projects, particularly during the execution stage.

Part III: Construction Project Management Responsibilities

The third part includes (13) questions concerning the construction project management responsibilities, which are detailed more below. Table 5 displays the analysis of the third part's elements, as well as the arithmetic mean and standard deviation for each paragraph and total average. A five Likert scale was used (always, often, sometimes, rarely, and never (no)).

Table 5 shows that: The results about question № (10) showed that, “The existence of an organization of powers and responsibilities to quality assurance” is the highest percentage of response level according to the point of view of specialists with (mean =3.50, SD=1.15). Where the management of projects is concerned with the organization of powers for quality assurance is important as each person performs the specifications and requirements for quality assurance. This result agrees with research (Khalid, 2005).

The results about question №(11) revealed that, “Existence of continuous plans to improve quality,” is the lowest result according to the point of view of specialists with (always =0.0%, mean=1.5, SD=0.71). This result manifests that there are no plans for continuous improvement and development of quality control methods in projects in terms of the adopting traditional methods of project management. Finally from the results in a table (3-6), the total average is (mean=2.3, SD=0.9). This result shows that there is a weakness in the responsibilities of the project management to control and quality assurance in the Iraqi construction projects. This result agrees with research (Hasan, 2011).

Table .4: Statistical analysis of items for the second part.

	Percentages of response levels%					Mean	S.D
	Always	**Often**	**Sometimes**	**Rarely**	**Never (NO)**		
1	2	3	4	5	6	7	8
1-The presence of a quality guide that explains the quality system in compliance with the quality policies and objectives of the project.	6.0	8.0	16.0	34.0	36.0	2.1	1.18
2-The presence of a process manual that outlines the operations of the departments in order to apply the quality aspects.	4.0	8.0	16.0	34.0	38.0	2.1	1.11
3-The presence of a quality control information system that is integrated.	2.0	2.0	6.0	30.0	60.0	1.6	0.86
4-The existence of defined administrative and technical relationships, as well as authorities and duties for quality control.	6.0	4.0	22.0	60.0	8.0	2.4	0.93

1	2	3	4	5	6	7	8
5-The availability of skilled and qualified technical experts for quality control tasks.	4.0	6.0	18.0	64.0	8.0	2.3	0.87
6-The presence of engineering awareness, demonstrating the necessity of quality control for engineers on both the implementation and oversight sides.	4.0	4.0	24.0	62.0	6.0	2.4	0.83
7-Cadres are being trained to improve their ability to regulate quality in building projects.	2.0	6.0	14.0	54.0	24.0	2.1	0.90
8-The availability of training and courses for current programs to improve the workers' competence and efficiency in the field of quality.	2.0	4.0	4.0	30.0	60.0	1.6	0.91

1	2	3	4	5	6	7	8
9-The installation of efficient and contemporary devices and equipment.	4.0	6.0	18.0	58.0	14.0	2.3	0.93
10-Commitment to delivering building supplies on schedule and according to technical criteria.	4.0	10.0	52.0	32.0	2.0	2.8	0.80
11-Agreement to hold project-related coordination meetings on a regular basis (owner, designer, and contractor).	4.0	6.0	30.0	54.0	6.0	2.5	0.86
Total Average						2.3	0.93

Table .5: Statistical analysis of items for the third part.

	Percentages of response levels%					**Mean**	**S.D**
	Always	Often	Sometimes	Rarely	Never (NO)		
1	2	3	4	5	6	7	8
1-The approach to the quality policy is determined by the project management.	4.0	2.0	30.0	58.0	6.0	2.4	0.81
2-Contractors with project quality management experience are chosen.	0.0	2.0	6.0	56.0	36.0	1.7	0.66
3-Commitment to quality objectives and orientations by the company in which you work.	8.0	8.0	20.0	38.0	26.0	2.3	1.19
4-Commitment to the construction project's quality specifications.	4.0	8.0	40.0	46.0	2.0	2.7	0.82
5-Quality standards are integrated into the company's policy.	6.0	14.0	30.0	44.0	6.0	2.7	0.99
6-Simplified quality requirements are announced.	4.0	6.0	52.0	30.0	8.0	2.7	0.87
7-Job quality specifications that satisfy the employer, as the work is receivedwithout complaint quality specifications that are constantly monitored and reviewed during the implementation.	0.0	6.0	14.0	50.0	30.0	2.0	0.83
8-Quality requirements are regularly monitored and revised during the implementation.	2.0	4.0	50.0	40.0	4.0	2.6	0.73
1	2	3	4	5	6	7	8

9-An attempt is made to adhere to and get a certificate of conformity to the Specified specifications.	4.0	8.0	14.0	46.0	28.0	2.1	1.05
10-The existence of an organization of powers and responsibilities to quality assurance.	20.0	34.0	30.0	8.0	8.0	3.5	1.15
11-Existence of continuous plans to improve the quality.	0.0	2.0	6.0	36.0	56.0	1.5	0.71
12-Personnel working on the project's quality system receive frequent training.	2.0	2.0	10.0	42.0	44.0	1.8	0.87
13-The presence of an explanation, statement, and justification for the construction project's quality system.	10.0	8.0	20.0	24.0	38.0	2.3	1.33
Total Average						2.3	0.9

Part IV: Use of Modern Software as Building Information Modeling to Control the Quality of Implementation

This part illustrates the current use of BIM in assessing the quality in the construction projects, including (5) questions below. Table 6 displays the analysis of the last part's elements, as well as the arithmetic, mean, and standard deviation for each paragraph while the last section used a (yes, no) question.

Finally, the results in a Table 6, as shown in Evaluation (no), and (mean=1.07, SD=0.16) based on expert judgments provide a total average, indicating that BIM is not employed in the Iraqi building projects. This finding is supported by research (Amer, 2018).

Table 6: Statistical analysis of items for the fourth part.

NO.	Item	Percentages of response levels%		Mean	Std. Deviation	Evaluation
		YES	NO			
1	Are BIM applications utilized to control the quality of building project implementation?	0	100	1.00	0.00	NO
2	Have you heard of BIM (Building Information Modeling)?	30	70	1.30	0.46	NO
3	Do you employ BIM technology in any of your projects?	0	100	1.00	0.00	NO
4	Do you realize how beneficial it is to employ contemporary software such as (BIM) to improve the quality of building project implementation?	2	98	1.02	0.14	NO
5	Do you believe there is a relationship between the usage of (BIM) technology and improved implementation quality?	4	96	1.04	0.20	NO
Total Average				1.07	0.16	NO

Relative Important Index

To investigate the significance of quality execution control in the Iraqi construction projects and construction project management responsibilities, a list of each was presented to the respondents, who were asked to evaluate each item in a five-grade system, which were already weighed on a scale of zero to one hundred, as shown in Table 7 , and the relative importance of each item was calculated using the equation (Al-shaikhli, 2015):

RII=(∑_(i=1)^(i=N)▒〖X_i.F_i 〗)/N

Where:

RII = Relative importance of item (i).

X_i = Grading range's average of item (i), see Table (3-7).

F_i = Frequency of responses in item (i).

N = Number of respondents.

Table 7: Five-grade system (Al-shaikhli, 2015).

NO.	**Grade**	**Range**		X_i
		Lower limit	Upper limit	
1	Unimportant	0	20	**10**
2	Slight importance	20	40	**30**
3	Average importance	40	60	**50**
4	Important	60	80	**70**
5	Very important	80	100	**90**

Tables 8 shows the relative significance of each item as estimated from the replies. After viewing the quality execution control in the Iraqi construction projects, the respondents were presented with the point of view and asked to assess them based on their own engineering sense, experience, and viewpoint.

Table 8: The relative importance of the quality execution control.

NO.	**The status**	**RII %**	**Grade**
1	2	3	4
1	The presence of a quality guide that explains the quality system in compliance with the quality policies and objectives of the project.	42.8	Average importance
2	The presence of a process manual that outlines the operations of the departments in order to apply the quality aspects.	41.2	Average importance
3	The presence of a quality control information system that is integrated.	31.2	Slight importance
4	The existence of defined administrative and technical relationships, as well as authorities and duties for quality control.	48.0	Average importance
5	The availability of skilled and qualified technical experts for quality control tasks.	46.8	Average importance
1	2	3	4
6	The presence of engineering awareness,	47.6	Average

	demonstrating the necessity of quality control for engineers on both the implementation and oversight sides.		importance
7	Cadres are being trained to improve their ability to regulate quality in building projects.	41.6	Average importanc e
8	The availability of training and courses for current programs to improve workers' competence and efficiency in the field of quality.	31.6	Slight importance
9	The installation of efficient and contemporary devices and equipment.	45.6	Average importanc e
10	Commitment to delivering building supplies on schedule and according to technical criteria.	56.4	Average importance
11	Agreement to hold project-related coordination meetings on a regular basis (owner - designer - contractor).	49.60	Average importance
12	The project partners' interest in the project's cost exceeds the needed quality.	80.00	Very important

From Table 8, it is clear that, “The project partners' interest in the project's cost exceeds the needed quality,” is relatively the most important (80%). The fact that, approximately, among the different circles of engineers Iraqi construction sector has the same trend towards in quality execution control axis.

However, while the rest of the paragraphs for the quality execution control axis was often average importance. Both items “The existence of an integrated information system for quality control” and “ The presence of training and courses for modern programs to raise the skill and efficiency of workers in the field of quality” scored relatively low importance according to this questionnaire with a percentage of (31.2%) and (31.6%), respectively which might be attributed to the lack of knowledge in the subject .

As in the Quality Execution Control axis, the Construction Project Management Responsibilities axis were also listed and presented to the respondents in order to evaluate their opinions according to the respondents’ experience and perspective. The relative importance of each item, as calculated from the responses, is illustrated in Table 9.

The most important paragraph, as shown in Table 9, is the “The existence of an organization of powers and responsibilities to quality assurance” with a relative importance of (70 %), This shows that there is a need to provide a quality department or even a professional as a quality manager, which is clearly tied to the project management of quality assurance.

Table 9: The relative importance of the construction project management responsibilities.

NO.	The status	RII %	Grade
1	The approach to the quality policy is determined by the project management.	48.0	Average importance
2	Contractors with project quality management experience are chosen.	34.8	Slight importance
3	Commitment to quality objectives and orientations by the company in which you work.	46.8	Average importance
4	Commitment to the construction project's quality specifications.	53.2	Average importance
5	Quality standards are integrated into the company's policy.	54.0	Average importance
6	Simplified quality requirements are announced.	53.6	Average importance
7	Job quality specifications that satisfy the employer, as the work is received without complaint quality specifications are constantly monitored and reviewed during implementation.	39.2	Slight importance
8	Quality requirements are regularly monitored and revised during implementation.	52.0	Average importance
9	An attempt is made to adhere to and get a certificate of conformity to the specified specifications.	42.8	Average importance
10	The existence of an organization of powers and responsibilities to ensure quality.	70.0	importance
11	Existence of continuous plans to improve quality.	30.8	Slight importance
12	Personnel working on the project's quality system receive frequent training.	35.2	Slight importance
13	The presence of an explanation, statement, and justification for the construction project's quality system.	45.6	Average importance

Conclusion

This article highlights the approach used to gather and evaluate data on evaluating the reality of execution quality in engineering projects in the public and private sectors. For the data analysis and computation of percentages, mean, and standard deviation for each response, statistical software (SPSS-V28) was utilized. As a consequence of the answer analysis, the author determined that there is a deficiency in the execution quality, project management's obligations to assure and regulate quality, and non-compliance. The current software is used to control execution quality. The author believes that there is a need to use modern and advanced Building Information Modeling programs to ensure and control quality that is characterized by accuracy and clarity, as well as to provide an integrated system to which project parties can return when needed

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