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The Effects of Building Information Modeling on Construction (Productivity and Cost)

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Abstract
Recently, a silence revolution has been taking position which will basically alter the very material of the audiovisual plan and addition business. This revolution is the greater than before use of Building Information Modeling (BIM). This study investigates the effects of Building Information Modeling on construction project productivity and Cost. The study sample was (50) managers of construction projects in Jordan. The researcher used descriptive method and developed a questionnaire to collect data. The results of the study showed that the mean of study paragraphs came high within field which measures the role of using Buildings Information Modeling in the cost of the project, t the mean of the paragraphs of the study came high within the field , which measures the role of using Building Information Modeling on productivity of construction, and that the differences was statistically significant for field which states "the role of the using Building Information Modeling in the productivity of construction in favor of diploma, and that the differences was statistically significant for field which states "the role of the using Building Information Modeling in the cost of construction in favor of bachelor, also the result of this study showed that there are no statistically significant relationship at the significance level ($\alpha \leq 0.05$) in the impact of the Building Information Modeling (BIM) on the productivity and the cost of construction projects due to the variable (gender, experience). This study recommended founding a Staff from company or outside it for training employees and to exercise particular programs to increase the requirements of Building Information Modeling (BIM).
Keywords: Building Information Modeling, Construction industry, construction projects, Productivity, Cost

Chapter one:
Introduction

Through the last three decades the construction industry has seen strong development of the use of information technology. The newest and most promising in these developments is the use of Building Information Modeling (**BIM**), (Eastman et al. 2011).

It can be described as a tool that enables storage of information and domain knowledge throughout the lifecycle of the project (Vanlande and Nicolle 2008). Therefore **BIM** has a major function to coordinate and integrate the substitute of information and knowledge between different departments and phases within the project. The use of **BIM** in a construction projects has both the potential benefit of improving product quality, and enabling more sustainable designs of buildings (Eastman et al. 2011).

BIM has come to increased sustainability and productivity within the construction industry. BIM is considered as a means of providing integrated and coherent information management strategy (BIS, 2011).

Study Problem:

There are several problems resulting from the evolution of construction and of expanding rapidly in construction productivity during the last period. However the multiplicity of construction problems caused this research and to solve productivity problems at construction project so that should apply and produce technologies as Building information Modeling. Scientific research centers of experiments aimed at further technical development of the means of more productivity makes us optimistic that the future holds a lot of innovations that can contribute more effectively in providing productivity with high Quality and safety for users.
So this research was to examine the effects of Building information modeling on construction project productivity and cost that can confront us and supporting decision making during the application of this system.

Hypotheses of study:

The study has a main hypothesis which is "There are effects of Building information modeling in construction project productivity and cost"

Sub-questions of study:

- Are there significant variations in the impact of Building information modeling in the project productivity ($\alpha \leq 0.05$)?
- Are there significant variations in the impact of Building information modeling in the project cost ($\alpha \leq 0.05$)?

Purpose of study:
The study has a main aim which is identify the effects of Building information modeling on construction project productivity.

Sub-aims of study:

- There are significant variations in the impact of Building information modeling in the project productivity ($\alpha \leq 0.05$).
- There are significant variations in the impact of Building information modeling in the project cost ($\alpha \leq 0.05$).

Significance of the study:
This study also shows how Building information modeling effect in construction projects, and how Building information modeling impact on productivity and cost of construction projects productivity.

Chapter two
Literature review
Introduction
This chapter discusses the effects of Building information modeling on construction project productivity and cost.

Building Information Modeling in Construction project
BIM in Management is a process involving the structured sharing and coordination of digital and non-digital information about a building project throughout its entire lifecycle, from design through procurement, construction and beyond, into the operation and management stage, all the way through to demolishment. It involves the efficient coordination of processes, workflows, people, documentation, graphic/non-graphic assets and technology.
But BIM is a digital representation of building process to facilitate exchange and interoperability of information in digital format.

Cost & Time are the benefits of BIM; the next step is to put together a software and hardware acquisition plan. This plan should include the cost of the software, the hardware and any additional staff needed. The Goal of this plan is to give management an idea of the scale of the investment needed. It should include yearly subscription costs, support costs for at least the first year of using the software, and any other costs associated with using the software. Potential hardware costs include additional RAM, disk space, servers, or network connections that are required. The software vendor can generally furnish this information.

BIM is an investment and need a significant cost; on the other hand, the potential savings and return on investment far out-weigh the cost of hardware and software, and can be purchased overtime.

Because many of the pieces of software require additional horsepower to make the software function correctly, this can make for a significant investment by the firm. Farther development of the plan should include adscription of each piece of proposed software, a rational for its use, the cost and estimates for the time to implement it and train personnel on its use.

Implementing a BIM solution is an endeavor in itself; to make the overall transition easier, a firm should not try to acquire and train people on multiple pieces of software at the same time. Identify specific pieces of software in the estimate that show the initial investment and time, and show what software is to be acquired later in the integration plan.

The goal of the acquisition plan is to give management a clear understanding of the total cost to implement the proposed solution and to secure ownership buy-in. Ownership may begin a conversion about which software production can get the fire to walk in BIM before everyone has to start running in it. The BIM manager should rely on the experience and guidance of management and senior staff develops a plan that everyone can support.

Construction industry is considered as the oldest industry known by human. It had prospered since long time ago. Moreover, it achieved advanced degrees in its products and ways to implement them. Old monuments as pyramid in Egypt, old roman theater and the Great Wall of China witnessed the greatness of this industry and its prosperity. Also, it witnessed the products of this industry which reflects the great culture and sophistication. The great diversity of its modern and civilized products, in which we live and with which we deal, emphasizes all that prosperity. These products affect human's daily life socially, politically and economically (Khatatbeh, 2014:p1).

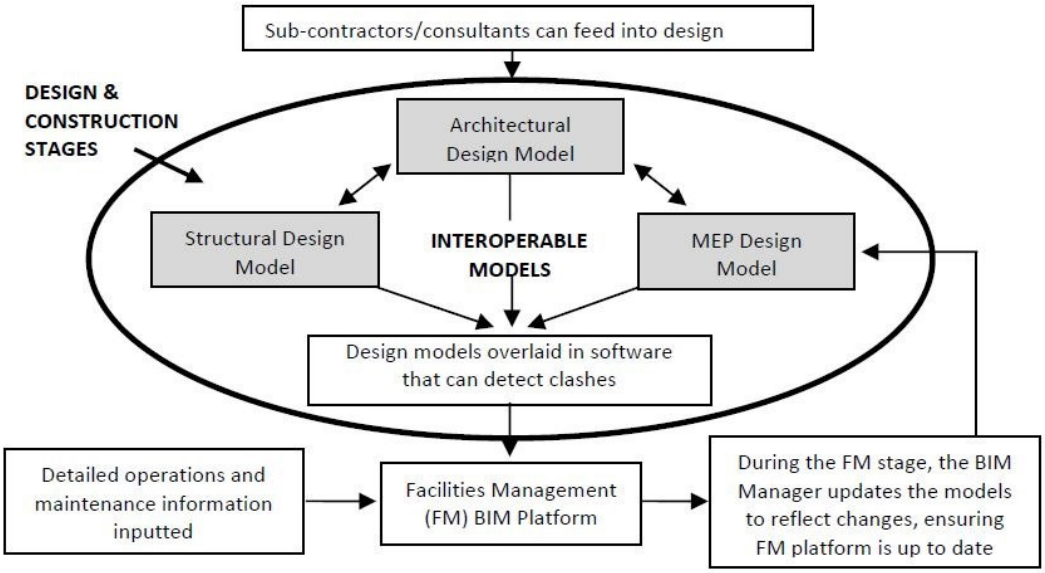
Previous Study:
The study of (Ibrahim, 2011) focused on Building Information Modeling in Architectural Education: The Case of the Middle East and UAE The construction industry in the 21st century is facing a huge challenge. Building Information Modeling (BIM) is emerging as a technological, procedural and strategic new approach to the fields

of Architecture, Engineering and Construction (AEC) providing a way for iterating, documenting and managing a design through most of its life-cycle from conceptual design, design development to construction through operations and management. Since CAD easily helps visualize the design concept, where the conceptual design phase is mainly there possibility of the architect, most curricula in architectural education are currently designed with more focus on CAD and less or no focus on BIM. As a result, most architecture graduates do not posses enough BIM knowledge or skills that are urgently needed by employers. This creates a growing gap between academia and the design and construction industry that needs to be addressed. Also, of great importance is the unique situation of each region of the world with its different infra structure and different work habits.

The study of (Baik et al, 2013) focused on the historic city of Jeddah faces serious issues in the conservation, documentation and recording of its valuable building stock. Terrestrial Laser Scanning and Architectural Photogrammetric have already been used in many Heritage sites in the world. The integration of heritage recording and Building Information Modeling (BIM) has been introduced as HBIM and is now a method to document and manage these buildings. In the last decade many traditional surveying methods were used to record the buildings in Old Jeddah. However, these methods take a long time, can sometimes provide unreliable information and often lack completeness. This paper will look at another approach for heritage recording by using the Jeddah Historical Building Information Modeling (JHBIM).

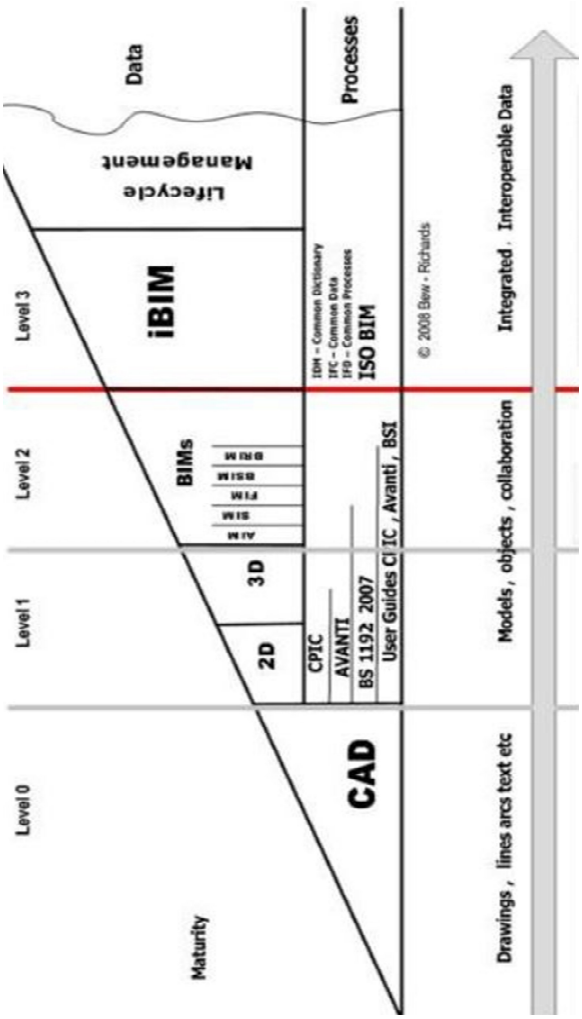
The study of (BIS, 2011) a report for the UK Government Construction Client Group: BIM has come to increased sustainability and productivity within the construction industry.BIM is considered as a means of providing integrated and coherent information management strategy.

This study of (Grilo and Jardim-Goncalves, 2010) focused on the idea of interoperability where it is hoped that this will work to reduce industry fragmentation and provide a smooth flow of information throughout the planning, design, construction and operation phases, as shown in figure 2. BIM as a tool can be used throughout the lifecycle with the intention to improve collaboration between stakeholders, and encourage quick and easy sharing of information, by bringing together the work of various disciplines, through a centralized model. This resulting model is a three dimensional digital representation of a facility, which should allow for reliable decision making throughout its life time.



Fig(1): Interoperable BIM Process (**Grilo and Jardim-Goncalves, 2010**)

The study of (Deutsch, 2011) spotted light on the main differences (dimensional wise) between BIM and the old process, where BIM provide to us 3D graphical modeling,4D time modeling and 5D cost modeling.



Fig(3): BIM Maturity Diagram (**Deutsch, 2011**)

Level 2 essentially requires teams to be working collaboratively with 3D BIM, however with no obligation for the 4D schedule, 5D cost and operation elements to be incorporated within the model.

Currently, the UK government is targeting all public projects to be delivered to a BIM 'maturity' level 2 by 2016. Level 3 represents a fully integrated BIM process, utilizing the models full potential, with the most complex being where clients are able to benefit from lifecycle asset management

The study of Coates, et al, 2010, represented the BIM Case study for John McCall's Architects (JMA) on how to Implement BIM. JMA works with a lot of stakeholders from the design through to building construction process, and the linked data is very disjointed. Projects in which JMA are involved are typically of 2½ years duration, involving many stakeholders and requiring considerable interoperability of documentation and dynamic information . The company was, therefore, required to improve its capacity for

1. Greater integration and collaboration with other disciplines in the production process,
2. Adopting technology change to provide a more effective business process,
3. Effective intelligent real time response,
4. Moving into related building sectors.

The benefits of previous studies:

- BIM is not perfect; it is a relatively new technology when compared with other industry slandered. BIM software was developed as response from design professionals who begin to see the need to create a single source of information that can be shared, add to, altered, and responsibility distributed among the design team.
- Construction engineering has obligation to future generations, to the environment, and to improve BIM technology.
- Gap in the awareness of cost consultants sampled in several significant zones, including the primary change to their role when working with BIM and appreciative the impending limitations of automatic

measurement.

This study will add to literature review of engineering management more reference to support the subject.

Chapter Three

Methods and Procedures

This chapter contains description of study methodology, population and sample in addition to the chosen method as well as tool used to collect data. Furthermore, practical procedures and statistical processing are used in the treatment of the study data as the following:

Study Methodology:

Researcher used descriptive analytical method which is based on the data collection, classification, organization and analysis.

Study population:

Population of the study consisted of all manager in the construction projects in Jordan.

Study Sample:

The study sample was selected randomly based on Demographic variables (age, gender, academic qualification, experience) from the population of the study equivalent to (50) managers of construction projects in Jordan.

Instrument of the study:

To Increase the construction project productivity and show the effect of Building information modeling on construction project cost in this study, the researcher built and developed a preliminary questionnaire consists of (10) items for this matter through revising the literature review and the previous studies which related to the content.

Reliability

To ensure instruments reliability and validity researcher presented preliminary questionnaire for a number of questionnaire arbitrators and judges whom are experts and specialized in this field and were selected in intentionality manner from some of manger of construction projects in Jordan. In order to ensure that each statement clarity and accuracy of the context, and how suitable is the form of the field which is being measured and their suitability to the aims of the study. The arbitrators for the preliminary study tool form an approval of 80% and more. Evidence of items sincerity was based on members' proposals of the arbitration, and has become in its final form consisting of four fields through (10) items. The level of scale of answers for each paragraph was according to five point Likert scale identified as follows: one represents Strongly Agree, two represents agree, three represents normal, four represent disagree, five represents strongly disagree. Likert scale was used to judge the results which were divided to High, Average and Low according to the following standard:

The highest value - minimum value of alternatives/ Number of levels

Therefore, the level of response as follows:

Low level if it was 1+1.33=2.33

Average level if it was 2.34+1.33= 3.67

High level if it was 3.86 and more = 5.00

Validity

To ensure stability, the researcher adopted the method of testing and retesting. Questionnaire has been distributed for number of quality mangers of construction projects in Jordan. Twenty mangers of construction projects are from outside the study sample, as it was re-applied to them after two weeks, where as the value of Pearson's correlation coefficient was 80%, its a high value and acceptable for the purposes of this study. The equation of Cronbach alpha also used for internal consistency, reliability coefficients were as follows:

Table (1) Stability Rate

Domain	number of paragraphs	Cronbach Alpha
impact of Building information modeling in the project duration.	4	78%
impact of Building information modeling in the project cost	4	71%
impact of Building information modeling in the quality assurance & quality management	6	81%
effects of using Building information modeling in design and construction regarding the contract parts modeling	6	81%

Table (1) Show that all domain s of study got a Ratio more than 80% this values is acceptable for the purposes of scientific research

Statistical treatment:

For achieving the purpose of statistical treatment, the following statistical methods were used:

1. mean and standard deviations.

2. T-test statistical (One Way Anova) and (Shaffee) test for dimensional comparisons where necessary.
3. the equation of Cronbach alpha and Pearson's correlation coefficient.

Chapter four
Results Analysis

- To answer the first question which states: What is the role of using Building Information Modeling on productivity of construction? It has been found the means and standard deviations of the field, which measures the role of using Building Information Modeling on productivity of construction projects, Table (3) shows that:

Table (3) Means and standard deviations of the field, which measures the role of using Building Information Modeling on productivity of construction

Applicability	Rank	Standard Deviation	Mean	Paragraph	n
High	1	0.85	4.45	Building Information Modeling contribute to reducing the need to reconstruction	4
High	2	0.56	4.32	Building Information Modeling work on assembling the necessary resources for the development of construction	3
High	3	0.61	4.08	Building Information Modeling Improve Project Quality	5
High	4	0.67	3.86	Building Information Modeling helps to reduce restructuring of construction project	1
medium	5	0.70	3.60	Building Information Modeling accelerate the process of enhancing communication and coordination	2
High		0.60	4.06	Performance As whole	

Table (3) shows that the mean of the paragraphs of the study came high within the field , which measures the role of using Building Information Modeling on productivity of construction to the answers of the study sample , where the mean of the total degree of applicability was of high (4.06) with a standard deviation of (0.6). Paragraph (4) which states that " Building Information Modeling contribute to reducing the need to reconstruction " came in the first rang with a mean of (4.45) and degree of applicability of high and in second rank came paragraph (3) which states that " Building Information Modeling work on assembling the necessary resources for the development of construction " with a mean of (4.08) and a degree of applicability of high. Paragraph (5) which states that "Building Information Modeling Improve Project Quality" with a mean of (4.08) and a degree of applicability of high ranked third. Paragraph (1) which states that " Building Information Modeling helps to reduce restructuring of construction project " with a mean of (3.86) and a degree of applicability of medium ranked fourth. The last paragraph (2) ranked fifth, which states "Building Information Modeling accelerate the process of enhancing communication and coordination" with a mean of (3.60) and a degree of applicability of high.

- To answer the second question which states: What is the role of using buildings information modeling in cost of the project? It has been found mean and standard deviations of the field, which measures the role of using buildings information modeling in cost of the project, Table (4) shows that:

Table (4) mean and standard deviations of the field, which measures the role of using buildings information modeling in cost of the project

Applicability	rank	Standard Deviation	mean	Paragraph	n
High	1	0.54	4.22	Building Information Modeling is working to control costs more effectively	3
High	2	0.61	4.10	Building Information Modeling is reducing expensive material to get biggest possible feasibility of project	1
High	3	0.68	3.88	Building Information Modeling is reducing the cost of project	2
High	4	0.50	3.79	Building Information Modeling is helping to determine cost of project before start designing	4
	5	0.49	3.73	Building Information Modeling is reducing human recourses with keeping the quality then the cost will reduce	5
High		0.57	3.94	Performance As whole	

Table (4) shows that mean of study paragraphs came high within field which measures the role of using buildings information modeling in cost of the project, where the total degree of applicability was high with a mean of (3.94) and standard deviation of (0.57). paragraph (3) which states that " Building Information Modeling is working to control costs more effectively " came in the first rank with a mean of (4.22) and degree

of applicability of high , paragraph (1) which states that "Building Information Modeling is reducing expensive material to get biggest possible feasibility of project " came at second rank with a mean of (4.10) and a degree of applicability of high, also paragraph (2) which states that " Building Information Modeling is reducing the cost of project " came at third rank with a mean of (3.88) and a degree of applicability of high, paragraph (4) which states that " Building Information Modeling is helping to determine cost of project before start designing " came at forth rank with a mean of (3.73) and a degree of applicability of high and the last paragraph (5) , which states " Building Information Modeling is reducing human recourses with keeping the quality then the cost will reduce," with a mean of (3.78) and a degree of applicability of the high came at fifth rank.

- To answer the third question which states: Is there a statistically significant relationship at the significance level ($\alpha \leq 0.05$) the impact of the Building Information Modeling (BIM) on the productivity and the cost of construction projects due to the variable (qualification, gender, experience)?

First: Qualification

To examine the statistically significant differences between the study sample responses in the field of study due the qualification variable, the researcher using unilateral variation analysis test and the following table shows the results of the test:

Table (5) Results of unilateral variation analysis test to show the effect of variable Qualification answers in the study sample analysis

The level of significance	Value F	Mea n of squares	Degrees of freedom	Sum of squares	Source of variance	Field
.000	80.958	1.723	2	3.447	Between groups	What is the role of using Building Information Modeling on productivity of construction?
		.021	47	.575	Within groups	
			49	4.021	Total	
.000	22.612	1.119	2	2.239	Between groups	What is the role of using buildings information modeling in cost of the project?
		.050	47	1.337	Within groups	
			49	3.576	Total	

Table (5) shows that there are differences between the responses of the study sample in relation to qualification variable were statistically significant at the significance level ($\alpha \leq 0.05$) where there were statistically significant differences in the first field which states " the role of using Building Information Modeling on productivity of construction " The second area which states "The impact of the use of buildings modeling information in the cost of the project" as the value of the significance level for areas less than ($\alpha \leq 0.05$) and to find out in favor of any of the groups were statistically significant differences a Scheff'e posttest was made and table (6) shows these results:

Table (6) :Scheff'e posttest results

MA	Bachelor	Diploma	Mean	Field	
2.93	3.78	3.33			
.000*	.000*		3.33	Diploma	the role of using Building Information Modeling on productivity of construction
.001*			3.78	Bachelor	
			2.93	MA	
Graduate	Bachelor	Diploma			the role of using buildings information modeling in cost of the project
2.86	3.67	3.08	Mean		
*.000	*.000		3.53	Diploma	
.167			3.08	Bachelor	
			2.86	MA	

1- Table (6) shows that the differences is statistically significant for first field which states "**the role of the using Building Information Modeling in the productivity of construction**," was among

the mean category of "diploma" and the category of "Bachelor" and by reference to the means for both categories, the values shows that statistically significant differences were in favor of the category of "Bachelor" and that got mean of (3.78), while the category of "diploma" got a mean of (3.33), the table shows that there is a statistically significant also among the categories (Diploma) and (Postgraduate), for first field and to the means for both categories, the values shows that statistically significant differences were in favor of the category of "diploma" and that got a mean of (3.33), while the category of "Postgraduate" got a mean of (2.93), also the table shows that there is a statistically significant relationship between the category (BA) and category (Postgraduate) for the first field and by reference to the means for both categories , the values shows that statistically significant differences were in favor of the category of ""Bachelor" and that got a mean of (3.78), while the category of "Postgraduate" got a mean of (2.93).

2- The second field, which states that "the impact of using buildings information modeling in the cost of the project" table (6) shows that there were statistically significant differences between the mean category of "diploma" and the category of "Bachelor" and by reference to the means for both categories values shows that statistically significant differences were in favor of the category of "Bachelor" and that got the mean of (3.67), while the category of "diploma" got the mean of (3.08), the table also shows that there is a statistically significant relationship between the category (diploma) and category (Postgraduate) for the second field and by reference to the means for both categories , the values shows that statistically significant differences were in favor of the category of " diploma " and that got a mean of (3.08), while the category of "Postgraduate" got a mean of (2.86).

Second: gender variable

To examine the statistically significant differences between the study sample responses in the field of study due the Gender variable, the researcher used t-test and the following table shows the results of the test:

Table (7): Means, standard deviations and the value of T for the answers of the study sample by gender variable

Felids	gender	Mean	standard deviations	value of T	The level of significance
the role of using Building Information Modeling on productivity of construction	Male	4.0456	.34980	.490	.340
	Female	3.1311	.78659		
the role of using buildings information modeling in cost of the project	Male	2.9801	.14527	.863	.216
	Female	3.0000	.21434		

Table (7) shows that the differences between the responses of the study sample in relation to the gender variable were not statistically significant in first field, which states that "the role of using Building Information Modeling in the productivity of construction," and the second field, which states that "the impact of buildings Information Modeling in the cost of the project, "which reached the level of significance value to these fields (0.340) and (0.216), respectively, where the value of the level of significance for the two fields was higher than ($\alpha \leq 0.05$).

Third: experience variable

To examine the statistically significant differences between the study sample responses in the field of study due the experience variable, the researcher used unilateral variation analysis test and the following table shows the results of the test:

Table (8) Results of unilateral variation analysis test.

The level of significance	Value F	Mean of squares	Degrees of freedom	Sum of squares	Source of variance	Field
.745	**.295**	**.130**	**2**	**.259**	Between groups	What is the role of using Building Information Modeling on productivity of construction?
		.440	**47**	**42.663**	Within groups	
			49	**42.923**	Total	
.929	**.074**	**.029**	**2**	**.058**	Between groups	What is the role of using buildings information modeling in cost of the project?
		.395	**47**	**38.319**	Within groups	
			49	**38.378**	Total	

The table(8) shows that the differences between the responses of the study sample in relation to experience variable were not statistically significant at the significance level ($\alpha \leq 0.05$) in each of the first field, which states "the role of using of Building Information Modeling in the productivity of construction" and the second field, which states "the impact of the using of information buildings modeling in the cost of the project," which reached the level of significance value to field more than ($\alpha \leq 0.05$).

Conclusions

As a result of this study conducted in the Jordan indicated that there is a role of using Building Information Modeling on productivity of construction and this role is very important for construction project, by the way there is a great possibility for productivity development in the construction project. In today's competitive world, the term ' productivity ' and its concepts are very important for the construction project. Also there is the role of using buildings information modeling in cost of the project, any way the buildings information modeling reduces the cost of project by working to control costs more effectively during management process in construction projects in Jordan, where construction projects in Jordan applied Building Information Modeling to contribute in reducing the need for reconstruction, and used the quality control method by measuring the differences in standards and compliance with the implementation Building Information Modeling, also the result of this study shows that there are differences between the responses of the study sample in relation to variable (qualification) were statistically significant at the significance level ($\alpha \leq 0.05$) where there were statistically significant differences in the first field which states " the role of using Building Information Modeling on productivity of construction " in favor of (MA), The second area which states "The impact of the use of buildings modeling information in the cost of the project" in favor of (Diploma), but the result of this study shows there are no statistically significant relationship at the significance level ($\alpha \leq 0.05$) in the impact of the Building Information Modeling (BIM) on the productivity and the cost of construction projects due to the variable (gender, experience).

Recommendations

1. Founding a Staff from company or outside it for training employees and to exercise particular programs to increase the requirements of Building Information Modeling (BIM).
2. Take on a policy of Building Information Modeling (BIM) for the configuration of long-term relationships with dealers.
3. Management's option must be done during competent and efficient devices suggestions.
4. Holding training courses for managers and employees on how to apply the Building Information Modeling (BIM in construction projects

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