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BUILDING INFORMATION MODELING ADOPTION IN NIGERIA'S PUBLIC-PRIVATE PERTNARSHIP CONSTRUCTION PROJECT

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ABSTRACT

Building Information Modeling (BIM) is the latest trend technological advancement which is playing a vital role in transforming the construction industry in terms of planning, design, construction and management. The issues identified in literature would contribute in accelerating the adoption of BIM in NGN construction industry, especially for designers and contractors. It is very important to interact with those in the construction industry, and investigate which factors form the basis is impacting the performance of construction industry. From the following dissertation it is observed that construction industry undergoes a great deal of risk by investing time and money in promotion of BIM, especially during times of economic recession. Advantages ofBIM as well as a lack of awareness of value added of BIM are identified. The problems associated with BIM interoperability as well as the degree of information leveraged from BIM are clearly understood. With the increase in governmental efforts to integrate BIM into the construction industry, the NGN will soon become a global leader in BIM.

KEYWORDS: BIM, CONSTRUCTION, INDUSTRY.

I. INTRODUCTION

Building Information Modeling (BIM) is the latest trend technological advancement which is playing a vital role in transforming the construction industry in terms of planning, design, construction and management. The use of BIM across construction industries in NGN has been increasing steadily over the years and is forecast to be the most widely used tool in the NGN construction sector.

The use of BIM in the construction industry forms the stepping stone to unify disparate technologies used in the life cycle of the construction project. Aranda-Mena et al. (2009) identified that the BIM enabled effective functioning of interdependent processes of planning, analysis, designing and construction.

Currently competitive advantage has been established in NGN some certain construction sectors including lean engineering, low carbon built environment solutions and other such aspects. BIM Taskforcegroup (2011) identified that these advantages have been made possible due to the increasing influence of technological advances in the form of construction engineering software. In order to promote a more effective capability assessment, the government and the industry will take measures to create further opportunities for the NGN construction sector. Oneof the vital measures promoted by the government is Building Information Modeling (BIM).

Advantages of BIM

The BIM or Building Information Modeling is distinct in its qualities and is very ahead of time when it comes to exhibiting its abilities. It renders architects, engineers, and construction managers the required interoperable

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program in order to fulfill their entire wish list. BIM is declared to be completely limitation free during utilization except for the potentiality of the users. The advantages achieved while using the BIM are:

- Conflict resolution – all flaws including conflicts are found out in advance, hence any modification in the drawings can be performed ahead of the construction process (Bryde et al., 2013).
- Adjusts costs as changes occur –modifications in the projects can be identified as time moves on. The amount spent on certain processes is observed as an investment in the BIM, following which modifying different objects will not only help collaborate with the design section but also enable real time cost estimation (Demian and Walters, 2013).
- Speeds up design/construction process – BIM helps in quick completion of processes such as planning, preliminary design development, or pre-planning for construction. However, the only process that cannot be influenced by the speed of BIM is the drawing process performed by the architect. Effective and creative designs are time consuming and cannot be created in a pressured environment. This program can be used to increase the speed during the creation of construction drawings (Underwood and Isikdag, 2010).
- Reduces ultimate cost – this takes place by reducing time for construction, accumulating a certain amount of revenue for transformation and taking care of changes as and when they occur (Eastman et al., 2011).
- Single entry – according to Aranda-Mena et al. (2009), when there is recording of a single aspect into the plan view of a drawing, it will be exhibited in the scheduling of doors and elevations (interior and exterior), as well as sectioning interior elevations, exterior elevations, and sections. If any changes are done, when an object is modified everything associated with it in the BIM change as well. Any modification in the estimation will definitely create a change in the BIM. Not only that, but it will also help to identify anything that changes right from substitutions of objects - i.e. electrical demands on panels after changing lighting for the building, etc.
- Alternates – as alternative scenarios and substitutions are not difficult to modify and change in a BIM, it provides the owners with a privilege to ask for different types of alternative designs and schedules in order to check how cost can be balanced (Jensen and Johannesson, 2013).
- Design optimization – vital for handling LEED issues (Flager et al., 2009)
- Conflict identification and resolution – this is appropriate for identifying locations for the working of suitable operations such as mechanical, electrical, and communication. The only constraint is that the contractor should see to that all the operations perform in the allotted spaces, otherwise there are chances for the occurrence of unnecessary conflicts, especially when the employees are asked to commence work in tight spaces (Garber, 2009).
- Constructability – details can be gathered to display how building components are assembled.
- Construction sequencing as well as scheduling – to view the progress made, the model has to be sequenced and scheduled. The use of 4D BIM modeling will help maintain the schedule of construction projects.
- Life cycle evaluations – solar energy and other non-renewable sources of energy use in building can be evaluated. This can be utilized for performing energy calculations in order to find out the cost for running the HVAC for a building. This is an added advantage for budgeting cost over time (ZabalzaBribian et al., 2011).
- Operational simulations: BIM enables real time view by animating the model in order to display the activity, e.g., how a medical facility would be used. It can be used to present how the patient would be transferred from ICU to a normal ward; or can depict real time simulation of operational function of the plant in order to ensure that all functionalities of the building can be met (Yan et al., 2011; Tse et al., 2005).

II. RESEARCH METHODOLOGY

The method adopted for this research work is known as mixed method of data collection which consists of both quantitative and qualitative mode of data generation. Furthermore, according to this method, qualitative tools are best suited to analyze content that is non-numerical in nature. Since the current study aims to gather information from numerical format (related to advantages and disadvantages of BIM technology, gaps in current process) as well as non-numerical format (impact on interoperability and degree of implementation), the mixed methodology is being chosen.

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Data collection method

The current study makes use of a closed ended questionnaire which is based on a structured framework. The objectives of the study were kept in mind when the questionnaire was being framed.

III. RESULT AND DISCUSSION

Response rate

For the questionnaire analysis a total of 80 respondents were reached. Of these 60 respondents were willing to take part in the study. It is further observed that only 48 responses were found to be complete and these were taken into account. It is further observed that of these 48 responses, the 26 responses which were from a design department were taken for the results of the qualitative analysis. It was observed that only five respondents agreed to take up the study of which only three responses were complete and taken for the study.

Company characteristics and understanding of BIM

Table 1: Number of years in construction business

Number of years your company has been in construction	Frequency	Percentage
1-3 years	8	16.7
4-5 years	17	35.4
5-10 years	19	39.6
More than 10 years	4	8.3
Total	48	100

The above table presents the number of years the construction company has been in business. It is observed that majority of the respondents worked in companies which have been a part of the NGN construction sector for 5-10 years (39.6%) and 4-5 years (35.4%). Very few respondents were from companies which had more than 10 years, experience (8.3%) or 1-3 years of experience (16.7%). These statistics indicate that the representative sample population is employed in companies which have been in a construction sector for a number of years and have greater chances of using BIM in their design and construction process.

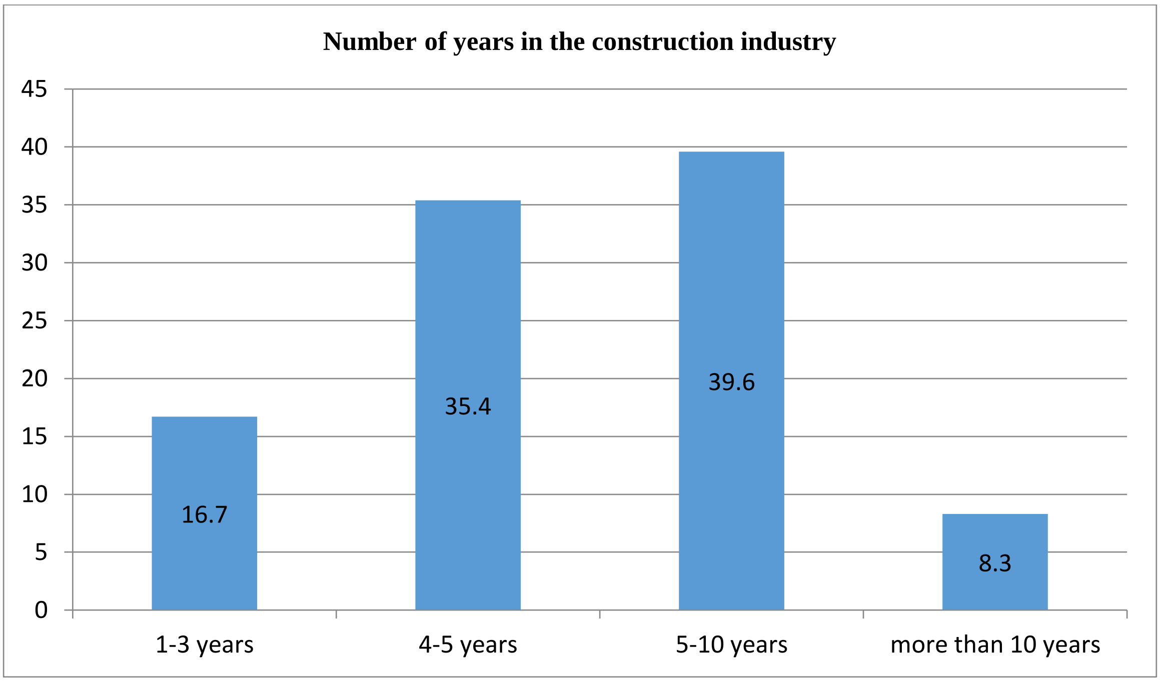

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Table 2: Type of construction operation

Expertise of your company	Frequency	Percentage
Buildings	16	33.3
Transport	13	27.1
Infrastructure	11	22.9
Hydraulic structures	5	10.4
Industrial buildings	3	6.3
Total	48	100

The above table presents the type of construction operation of the companies which have been in business. It is observed that majority of the respondents worked in companies which were involved in construction of buildings (33.3%),(27.1%) and infrastructure (22.9%). Very few respondents were from companies which were involved in rising of hydraulic structures and industrial buildings (10.4%) and (6.3%) respectively. The above statistics indicate that respondents work in construction companies which are involved in building, transport and infrastructure operations. Since the BIM tool is largely applicable to buildings construction, representation by a majority of the sample population in this section presents a greater advantage of them having used the BIM tools personally.

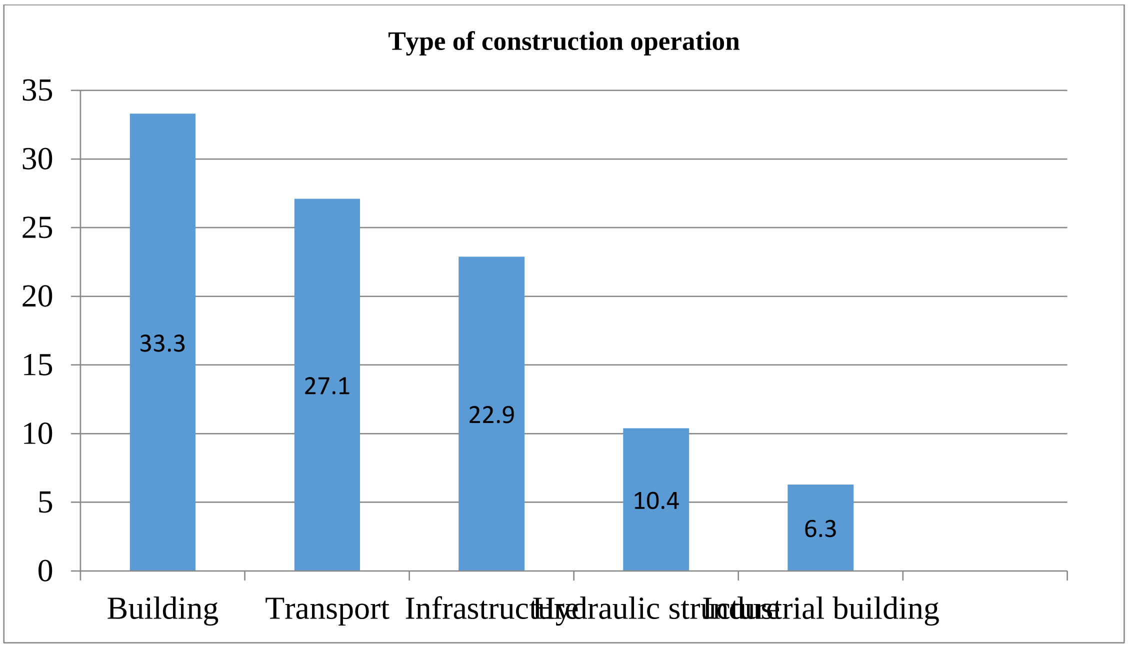

Figure 3: Type of construction operation

Table 3: Department of employment

Which departments are you currently employed in?	Frequency	Percentage
Design and engineering department	26	54.2
Field operations department	22	45.8
Total	48	100

The above table presents the employee. It is observed that the majority of respondents were found to be employed in the design and engineering department respondents in field operations (employees between the two sectors will facilitate comparison of views on BIM across these two departments.

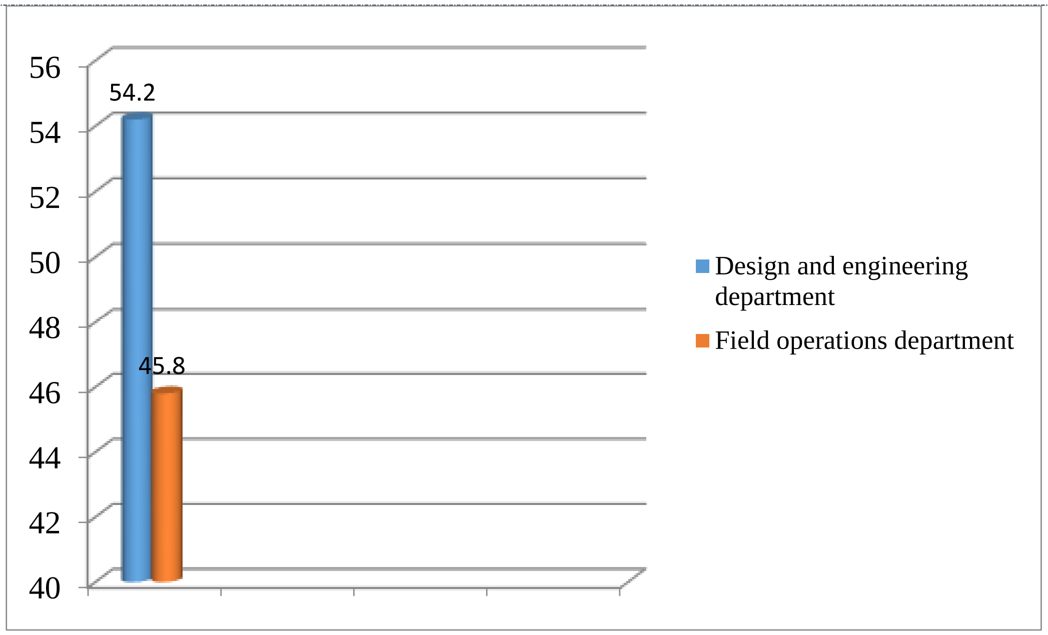

Figure 4: Department of employment

Table 4: Definition of BIM

Department of employment	**Definition of BIM**				**Total**
	BIM is 3D CAD tool	**BIM is an open standards based information repository**	**BIM is general contractor's virtual tool**	**BIM is government supported tool for property management**	
Design and Engineering Department	13	13	0	0	26
	100.0%	100.0%	0.0%	0.0%	54.2%
Field operations department	0	0	11	11	22
	0.0%	0.0%	100.0%	100.0%	45.8
Total	13	13	11	11	48
	100.0%	100.0%	100.0%	100.0%	100.0%
Pearson Chi-Square 48.0		p-value 0.001**			

**statistically significant at 1% level

The above table and following figure presents comparison of the perception of definition of BIM by respondents based on their department of employment. The majority of the respondents in the design and engineering department identified that the role of BIM is to be presented as a 3D CAD tool (13 respondents) and as a standards based information repository (13 respondents). In contrast, when respondents in the field operations were considered, BIM was considered from the perspective of a contractor as a virtual tool (11 respondents) and a tool supported by the government for management of property (11 respondents). This, accompanied by a Chi-Square value of 48.0 and p-value of 0.001, indicates that there is a degree of association between perception of BIM and the designation of the employee.

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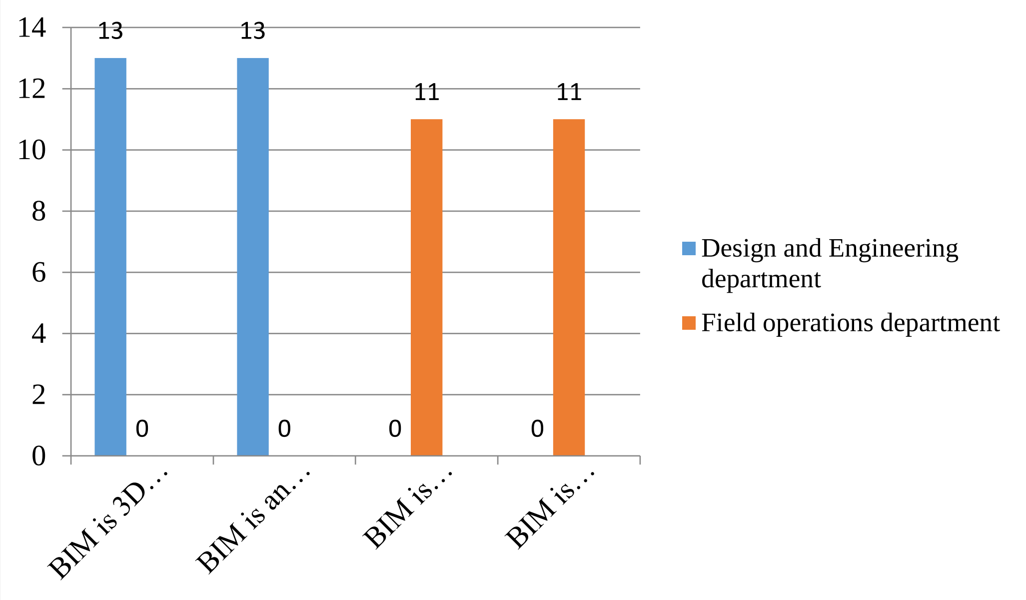

Figure 5: Definition of BIM

Advantages and disadvantages of BIM

Table 5: Descriptive statistics of advantages and disadvantages of BIM

Advantages and disadvantages of BIM	N	Minimum	Maximum	Mean	Std. Deviation
Advantage BIM	48	2.00	4.29	3.1042	0.39177
Disadvantage BIM	48	1.83	3.67	2.9618	0.46029

The above table presents the descriptive statistics of advantages and disadvantages of BIM. It is observed that the respondent perception of advantage spectrum ranging from 2.00 (Disagree) to 4.29 (Agree). Similar trends are observed with respect to perception of disadvantages of BIM ranging from 1.83 (Strongly Disagree and Disagree) to 3.67 (Neutral and Agree)

Table 6: Perception of advantages of BIM

Advantage BIM	Mean	Std. Deviation	t-test	p-value
BIM plays a vital role in conflict resolution	3.96	1.091	25.143	0.001**
The use of BIM adjusts costs as changes occur	4.13	1.178	24.255	0.001**
The use of BIM reduces overall cost	4.08	1.108	25.540	0.001**
There is speeding up of the design process	3.02	0.812	25.779	0.001**
There is optimization of the construction process	2.96	0.459	44.620	0.001**
Operation simulations can be carried out	1.81	1.024	12.259	0.001**
Life cycle evaluations can be carried out	1.77	1.016	12.080	0.001**

The above table presents the respondent perception of advantages of BIM. It is observed that different aspects including role in conflict resolution (Mean = 3.96, SD = 1.091), adjustment of cost (Mean= 4.13, SD=1.178) and reduction in overall cost (Mean=4.08, SD=1.108) present an above average mean score. This indicates that the majority of respondents felt these attributes to be major advantages.

However, the majority of respondents were of the opinion that there is limited impact of BIM on the actual design process (Mean = 3.02, SD=0.812).

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Furthermore the majority of respondents questioned the role of BIM in the construction process (Mean = 2.96, SD=0.459), operation simulations (Mean =1.81, SD=1.024) and life cycle evaluations (Mean =1.77, SD=1.016) by showing a very low score. This is indicative of most of them presenting disagreement with the advantages of the above attributes.

Table 7: Perception of disadvantages of BIM

Disadvantage BMI	**Mean**	**Std. Deviation**	**t-test**	**p-value**
Lack of interoperability	4.15	1.031	7.698	0.001**
Lack of standards of BMI	4.10	1.096	6.978	0.001**
Reluctance to use electronic data transfer	1.75	0.887	-9.7693	0.001**
Legal risks are associated with BIM	1.90	0.994	-7.693	0.001**
Number of personnel trained in BIM is less	4.00	1.130	6.132	0.001**
BIM has a steep learning Curve	1.88	0.914	-8.529	0.001**

The above table presents the employee perception of disadvantages of BIM. It is observed that different aspects including role in interoperability (Mean = 4.15, SD =1.031), lack of standards of operations (Mean= 4.10, SD=1.096) and lesser number of trained personnel (Mean = 4.0, SD=1.130) are found to show above average mean scores. This indicates that the majority of respondents felt these attributes to be major disadvantages.

However, other attributes like reluctance to use electronic data (Mean=1.75, SD=0.887), legal risks (Mean = 1.90, SD=0.994) and steep learning curve (Mean=1.88, SD=0.914) show very low mean scores. This indicates that the majority of respondents did not consider these attributes to be major disadvantages.

Value addition of BIM

Table 8: Descriptive statistics for value added of BIM

Perception of value added of BIM	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Planning	48	2.33	5.00	4.2847	0.57113
Marketing	48	2.33	3.00	2.9931	0.40382
Corporate strategy	48	1.00	3.00	1.8194	0.46615
Collaboration	48	3.00	5.00	4.1250	0.46446
Operation	48	2.33	4.00	3.0903	0.38739

The above table presents the descriptive statistics of value added features of BIM. It is observed that the respondent perception of collaboration, planning, and operation range between neutral to strongly agree. In contrast respondent perception of corporate strategy and marketing ranges from disagree to neutral. The comparative statistics are presented in the following figure.

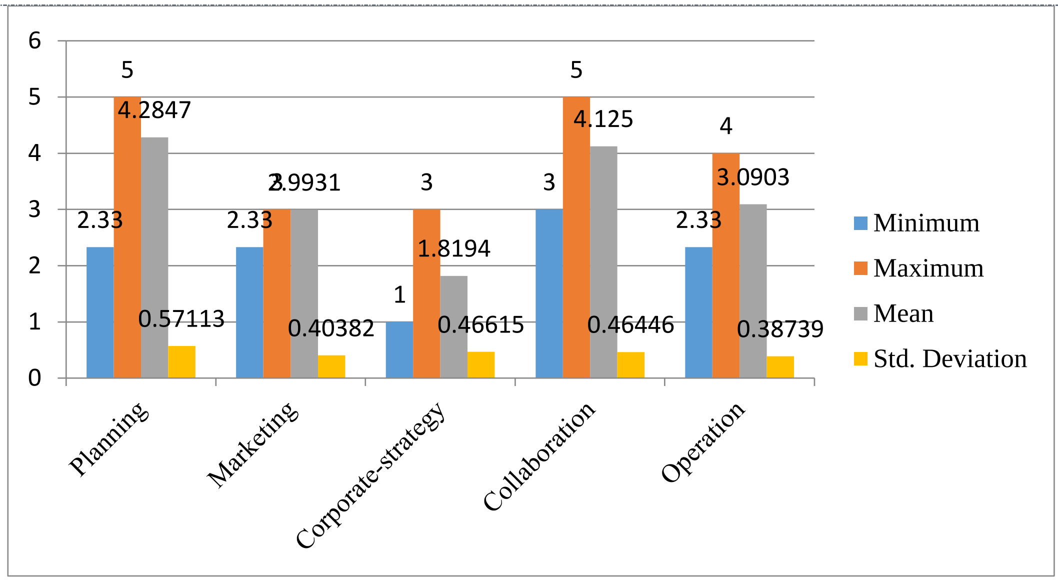

Figure 7: Descriptive statistics for value added of BIM

Table 9: Perception of value addition of BIM

Perception of value added of BIM	Mean	Std. Deviation	t-test	p-value
Effective project scheduling is carried out through BIM	4.38	1.024	29.610	0.001**
The use of BIM is implemented in the material and equipment staging	4.35	0.911	33.125	0.001**
BIM models are used in both designing and construction phase to plan the work progress	4.13	1.084	26.359	0.001**
There is effective recognition of business and marketing aspects of BIM in our organization	2.92	0.739	27.345	0.001**
Previously designed BIM models can be used for future business	2.98	0.601	34.340	0.001**
BIM strategies are firmly integrated into the firm's marketing content	3.08	0.710	30.104	0.001**
Implementation of BIM in my organization is by a dedicated BIM department	1.73	0.844	14.194	0.001**
There is clear delineation of BIM capabilities to clients	1.77	0.994	12.337	0.001**
Established BIM vision linking into firm's philosophy and goals is present	1.96	1.010	13.437	0.001**
Development of detailed BIM models for construction use is by design teams	4.02	1.062	26.238	0.001**
Construction superintendents have the final say on design of BIM models	4.27	0.962	30.764	0.001**
BIM enables better translation of design to implementation	4.08	0.942	30.046	0.001**
BIM use in field enables automation of layout erection and construction and thereby ensures calculation of plans	3.15	0.652	33.428	0.001**
All field personnel have access to BIM software	3.08	0.710	30.104	0.001**
BIM for the construction project is designed within the company	3.04	0.582	36.212	0.001**

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The above table presents the employee perception of value added of BIM.

It is observed that different aspects including role in effective project (Mean = 4.38, SD = 1.024), management of material and equipment (Mean= 4.35, SD=0.911) and work progress (Mean=4.13, SD=1.084) shows high mean scores. This is indicative of respondents strongly agreeing to the role of BIM in project planning.

When the role of BIM in promoting marketing operations is observed, it is seen that BIM plays a role in promoting the firm's marketing (Mean =3.08, SD=0.710). However the role of BIM in generating future business (Mean = 2.98, SD=0.601) is limited.

When the role of BIM in promoting identifying corporate strategy is observed, it is seen that problems are associated with implementation by separate departments (Mean=1.73, SD=0.844), clear delineation of role of BIM (Mean = 1.77, SD=0.994) and promotion of role of BIM in firm's philosophy (Mean = 1.96, SD= 1.010), which are all found to show a low score.

It is observed that aspects related to operations including design teams (Mean =4.02, SD=1.062), role of superintendents in deciding BIM (Mean=4.27, SD=0.962), design to implementation (Mean= 4.08, SD=0.942) were found to show an above average mean score, indicating that this is a very important aspect.

However it is also found that attributes of operation are found to be understood in a limited manner. Attributes including automation of layout (Mean=3.15, SD=0.652), field personnel (Mean= 3.08, SD=0.710), construction design (Mean=3.04, SD=0.582) are found to show neutral mean score, indicating lack of importance given to operation related aspects.

Impact of BIM on KPI

Table 10: Descriptive statistics for impact of BIM on KPI

Impact of BIM on KPI	N	Minimum	Maximum	Mean	Std. Deviation
Operational factors	48	2.50	5.00	4.2708	0.66010
Efficiency factors	48	1.00	3.67	1.7431	0.54247
Strategic factors	48	2.50	4.25	3.4271	0.42200

From the above table it is observed that impact of BIM on KPI is recognized. It is observed that the respondent perception of operational factors and strategic factors range from disagree to strongly agree. In contrast efficiency factor ranges from strongly disagree to strongly agree. The comparative statistics are presented in the following figure.

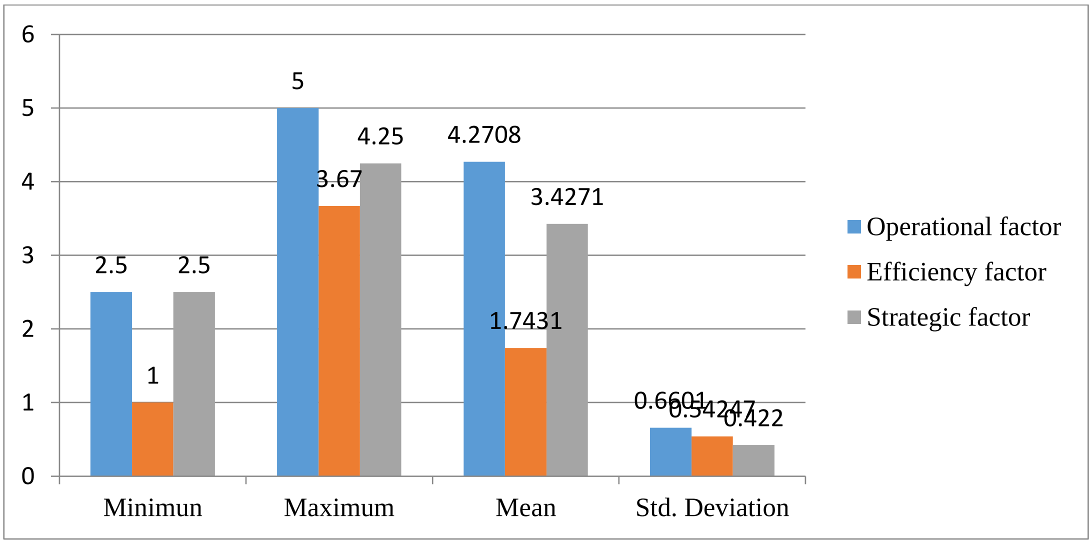

Figure 8: Descriptive statistics for impact of BIM on KPI

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Table 11: Perception of impact of BIM on KPI

Impact of BIM on KPI	Mean	Std. Deviation	t-test	p-value
Cost per hour of operation	4.25	1.062	27.728	0.001**
Information carrying cost	4.29	0.922	32.264	0.001**
Cost of distribution	1.71	1.010	11.722	0.001**
Labor utilization	1.73	0.844	14.194	0.001**
Overhead percentage	1.79	1.051	11.811	0.001**
Order lead time	3.48	0.772	31.241	0.001**
Flexibility of service systems to meet particular customer needs	3.44	.823	28.948	0.001**
On time completion	3.35	0.838	27.742	0.001**
Quality and Safety	3.44	0.681	34.959	0.001**

The above table presents the employee perception of impact of BIM on KIP. It is observed that different aspects including efficiency factors like role in cost per hour of operation (Mean = 4.25, SD = 1.062) and information carrying cost (Mean=4.29SD=0.992) and strategic factors including flexibility of service (Mean = 3.44, SD=0.823), on time completion (Mean =3.35, SD=0.838), and quality and safety (Mean =3.44, SD= 0.681) are found to show above average mean score.

However operational factors including cost of distribution (Mean=1.71, SD=1.051) and labor utilization (Mean = 1.73, SD=0.844) are found to show a below average mean score.

Qualitative interview results
The respondent views on interoperability issues are identified from this section.

Benefits of promoting interoperability
When the design engineers were questioned about the benefits of promoting interoperability it was observed that productivity, coordination and reduction in labor were the most commonly identified attributes, as seen in the following statements.

DM1: "I think interoperability promotion in BIM will help increase productivity in document development and coordination."
DM 2: "I find that better interoperability will promote better building design."
DM3: "I think interoperability will help a faster less labor intensive drawing review."

Issues of Interoperability
When the design engineers were questioned about the interoperability issues that arise by using different BIM software from the same vendors, most of them indicated that there are limited problems. However, they also indicated that this is not practical and may not be useful in designing an entire building. These views are observed from the following statements.

DM1: "I think there are limited issues of BIM interoperability when it comes to the same vendor. In my organization we use same vendor; this reduces the problems which arise."
DM2: "In my organization the service engineer, architect and the structural engineer may all work on separate models of the building but we use the same software. This helps us align and combine the designed model. However, this cannot always be done."
DM3: "There are no interoperability issues when we use software from the same vendor. We find that this gives us ease of coordination. But, I don't think this is practically applicable."

When questioned about the problems that arise due to interoperability issues among different software vendors the most commonly identified problem is the inability to agree on communication roles. However, the respondents feel that vendors are taking efforts to overcome the interoperability issues. This is observed in the following statements.

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DM1: "When designing a building I find that it is next to impossible to use software from a single vendor. The specifications needed by the design team require details of different products and solutions. I find the greatest problem with interoperability being the inability to agree on communication roles."

DM2: "I find that most of the software vendors take efforts to deal with interoperability issues. For example the design specifications using NBS create can be used in ArchiCAD. I find that conflicts in drawing and specifications between the software are often clearly indicated."

DM3: "I think interoperability between software from different vendors will help reduce coordination of project information."

Type and degree of information

It is observed from the research that during the preconstruction phase the degree of information leveraged is related to visualization of design as well as collaboration between the design teams.

DM1 "I think we are able to clearly visualize the final building even before ground breakup."

DM2 'I think the use of BIM has helped us share information between design architects, structural engineer and construction managers.'

In the construction phase respondents presented the view that they strongly identified with the role of BIM to leverage information on coordination, cost adjustment as well as time delay

DM3 "During the construction phase, the delay forecast (time and cost) is clearly presented using BIM. This information is very useful"

DM4 "I think the information on collaboration and degree of coordination between design team and operations team is clearly observed."

IV. CONCLUSION

From this study, it is observed that the construction industry subjects itself to a great deal of risk by investing time and money in promotion of BIM, especially during times of economic recession. Advantages of BIM as well as a lack of awareness of value added of BIM are identified. The problems associated with BIM interoperability as well as the degree of information acquired from BIM is clearly understood

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