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Effect of Building Information Modelling on Projects Implementation: A Case of Nairobi County

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Abstract: **The construction industry is transitioning rapidly towards modernization with Information Communication Technology (ICT) playing a significant role in this transformation giving birth to customized technologies and applications that suite the industry. It is therefore important that to understand what this transition constitutes by addressing the gap in knowledge of BIM use for Project Management in Nairobi County. Thus, the main objective was to determine effect of building information modelling on projects implementation in Nairobi County. The research was guided by four objectives within the study area of Nairobi County: to establish the effect of building information modelling (BIM) in design on project implementation; to determine the impacts of building information modelling in project estimation project implementation; To examine the role building information modelling in project scheduling on project implementation and to explore building information modelling in information asymmetry management on project implementation in Nairobi County. The study targeted 230 management from 43 projects in Nairobi County. Simple random was used to select a sample of 144 management. The research design that was employed was survey research, in which data from members of a population were collected to determine the status of that population with respect to the variables under study. The survey research was exploratory in establishing the effect of BIM in construction project management by asking individual respondents working in target organizations about their perceptions and personal experiences with respect to BIM use in construction projects. Data was collected qualitatively and quantitatively and analysed by SPSS version 23.0. The findings revealed BIM project design positively and significantly influences project implementation success, BIM project estimation positively influences project implementation success, BIM project scheduling has a positive and significant effect on project implementation success and information asymmetry has the potential to influence project implementation success. Furthermore, the county makes use of BIM project scheduling in resource allocation at all the project stages. However, the county rarely uses BIM to create project scheduling pie charts and bar charts. The study recommended that stakeholders involved in construction projects need to make efforts towards ensuring that there is BIM project estimation so that they can effectively make changes to the building model. Besides, there is need for the county to utilize BIM in adding and assigning activities and resources. As well, clients need to have access to BIM in an effort to enhance transparency and reduce instances of information asymmetry.**

Keywords: **Building Information Modelling, Computer Aided Design (CAD), Project Management, Information Asymmetry.**

1. INTRODUCTION

[12] Argued that because of this bilateral dependency between the principal and agent, hold-up costs are likely to increase as project-specific dependency increases. In this context, [1] argue that change orders cannot be wholly averted while adopting typical contractual measures, causing the pricing of additional work to rely on the bargaining power of parties involved in a contract. They further assert that the principal is still potentially in a weak bargaining position in such situations. To alleviate this problem, they recommend that the principal choose a procurement system with characteristics that match the project's attributes.

Therefore, it is not surprising that information asymmetry causes increased resources and transaction costs when procuring construction projects [9]. Even so, it is apparent from the preceding discussion that these transaction costs are not easy to quantify or avoid because, by definition, information asymmetry takes advantage of the hidden information. In protecting against the effects of information asymmetry, the principal is likely to incur additional costs such as governance costs or bonding expenditure. Alternatively, they are liable to bear losses due to the opportunistic behavior of the agent. Given these issues, managing information asymmetry could help to reduce project-based procurement risks [13].

It is therefore evident that the construction industry is transitioning rapidly towards modernization with Information Communication Technology (ICT) playing a significant role in this transformation giving birth to customized technologies and applications that suite the industry. The use of ICT permeates various industries and is widely seen as a major driver for improvement of performance and efficiency [2]. ICT has facilitated the success of projects in the modern construction industry through effective collaboration among the various stakeholders. Project information is communicated to all key stakeholders involved to assist in making thousands of decisions during the project lifecycle with Information technology application playing a vital role in the project collaboration and delivery.

2. EMPIRICAL REVIEW

BIM is one of the most significant new tools to arrive at the construction scene in the last generation, and it is gaining an increasing amount of attention in the industry. When CAD was initially introduced, it was seen by most as a tool that was not much more than a computerized means to a two-dimensional drawing. But CAD eventually proved very useful, evolving from drawing to modeling, and bringing into existence other complimentary tools that collectively were a much more efficient method to developing products [6]. Most would agree that CAD tools are now enabling engineering feats that would not be possible without them. BIM is following a similar pattern.

In their extensive handbook on BIM, Eastman, [11] advocate the benefits of BIM using integrated project delivery (IPD). Contracting methods under this form of procurement clearly define information-sharing arrangements among the stakeholders involved in the project [5], and enable the client to play an active role in decision making at all levels hence creating opportunities for reducing information asymmetry. [14] state that the open communication and exchange of data as afforded by the team-oriented BIM approach will facilitate more informed decision making and should also facilitate greater information transparency.

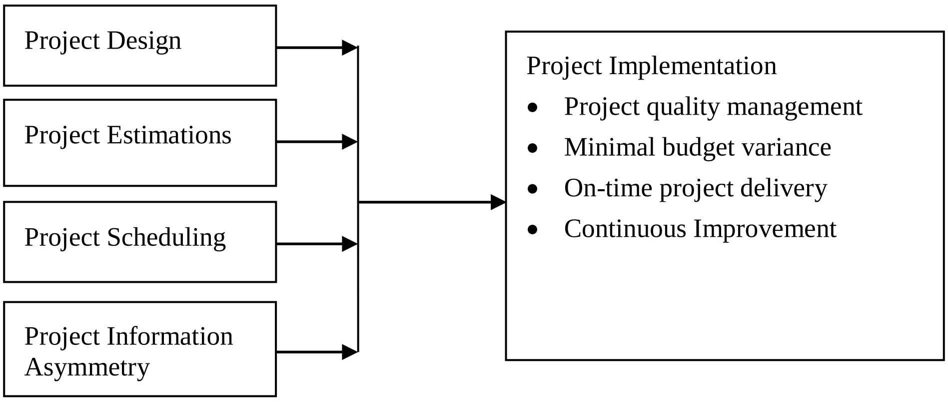
Even though the use of BIM in the construction industry is growing rapidly, not everyone has embraced this new tool [8]. People have a natural tendency to resist change, and those in the construction industry are perhaps more prone to that resistance than others. Because BIM represents such a significant difference in how projects are run, some established members of the industry are naturally resistant to its adoption. Working in such a new way is a challenge. So many of the work processes have been developed over time to the point that people are only comfortable working in that one familiar way. For these people to then switch to working with a model of a building, as much as the model is superior to the paper drawings, seems to leave many with a feeling of less control. Where people were accustomed to anticipating issues in the construction process, they continue to look for such problems on site when such issues did not exist in the model. With BIM, there appears to be a learning curve associated with the notion of trusting the model [3].

The value that the new tool brings must be demonstrated. In some cases, BIM is being viewed in the industry as a sort of toy for the younger generation. As if those who came from the video game generation just cannot seem to separate work from play [8]. But slowly it is being recognized that people are performing real work and achieving actual results through the use of BIM [8]. How this will be shown as having a positive return on investment has yet to be seen. But BIM is far from an all or nothing tool. There are various levels of BIM implementation, and that will allow different users to get into the BIM environment as slowly as they wish, and with a corresponding degree of investment [4].

As is the case with many new technologies, BIM is also gaining a foothold in the industry through the academic world. Companies who provide BIM solutions, the actual software, are heavily involved at the university level. They are promoting BIM solutions to those they see as the future users in the industry. The level of support that has been observed is an investment for these companies, but it appears to be one that may pay off, as the next generation of architecture, engineering, and construction professionals are quick to see the implications and advantages of this tool in the future [8]. Students in many programs are increasingly requesting courses in BIM as they see it as being a part of their future career. But there is still some caution on the part of the academic institutions. They want to ensure that the students always learn the basics, such as traditional drafting, before abandoning the basic skills for the higher technologies. That seems to be the approach that was taken when other new technologies, such as CAD or FEA (finite element analysis), were introduced to traditional curricula in the past [8].

3. CONCEPTUAL FRAMEWORK

Independent variables **Dependent Variable**



4. SUMMARY AND CRITIQUE OF EXISTING LITERATURE

As much as BIM is the next great enabler to successful construction, it is not without issues. From its conception, it was recognized that one of the most significant problems to address in an industry of varying BIM packages was interoperability [7]. As a building model is created in one software package, there is no guarantee that everyone else downstream in the construction process will be using the same software package. It is quite likely that different architects, engineers, contractors, and significant subcontractors will have different software packages. For this reason, interoperability has been one of the primary goals of most BIM providers.

As the tool continues to evolve, providers of BIM software are seeking the input of its users to define what feature they feel will be required and the most useful. Although there is a consensus on some of the major pieces, such as creating documents and maintaining an object-oriented model, many features may be of varying importance to different users [10]. Ideally, any model can be brought together into the same space as another model and an analysis of the two completed, regardless of the software in which each of the models was created. Although many offering BIM solutions are claiming to be compatible with other model formats, the potential for issues always exists. Whether it is a matter of absolute compatibility or just an issue of efficiency when moving from one BIM package to another, how this issue of interoperability affects the adoption of this tool throughout the industry has yet to be seen.

5. RESEARCH METHODOLOGY

The study adopted a descriptive survey design used to allow the researcher to gather, summarize, present and interpret information for clarification. The target population of the study included construction project management practitioners within Nairobi County. The study population targeted 230 Architectural/Engineering and Quantity surveying consulting practitioners registered with the professional body of ACEK (Association of Consulting Engineers of Kenya) and AAK (Architectural Association of Kenya. Census was undertaken to determine a suitable target population from the 230 management of 43 projects and a stratified random sampling technique utilized. The sampling frame of the study was the management of all projects implemented in Nairobi County. The sample size for the study was 144 participants to whom questionnaires were provided. The sample size of approximately 144 respondents was selected using the stratified random sampling technique. Data collection instrument used was the questionnaire

6. RESULTS AND DISCUSSION

Response Rate:

In this study, Out of the one hundred and forty-four respondents who were sampled and the questionnaires were administered, one hundred and fifteen respondents responded. This gave a response rate of 79.2% percent. The study variables had alpha coefficients higher than 0.7. This meant that the collected data were reliable as they had a relatively high internal consistency and could be generalized to reflect opinions of all respondents in the target population.

Based on the results, 70(60.9%) of the respondents were male while 45(39.1%) were female. Evidence from the findings suggests that mostly male individuals are involved in the construction projects in Nairobi County. The study settled on five age groups, from which, respondents were asked to identify their respective ages. The groups were 18 to 25 years, 26 to 33 years, 34 to 41 years, 42 to 49 years and those over 50 years. The data collected revealed that 16.5% of the respondents were aged 18 to 25 years, 35.7% were aged 26 to 33 years, 16.5% were aged 34 to 41 years, 28.7% were aged 42 to 49 years and 2.6% were aged over 50 years. Overall, the bulk of the employees are between 26 and 33 years.

The study sought to determine employees' job tenure in project management. This was meant to ascertain the extent to which their responses could be relied upon to conclude the study problem. In terms of job tenure, 44(38.3%) of the employees had worked on the project for a period ranging from 1 to 5 years, 24(20.9%) for 6 to 10 years, 10(8.7%) for 11 to 15 years, 9(7.8%) for 15 to 20 years and 28 (24.3%) of the employees had worked for over 20 years. These findings suggest that most of the employees had worked on the project for over five years; hence they could be relied upon to provide accurate information on the effects of building information modeling in construction projects implementation

6.1 BIM in project design:

The results from the study revealed that, of the total respondents, 28 (24.3%) strongly agreed that the county uses building information modelling in minimization of design errors, 53(46.1%) of them agreed, 4(3.5%) disagreed, 7(6.1%) strongly disagreed while 23(20%) of the respondents were neutral on this item. The mean value of this item was 3.79, and the standard deviation was 1.047. These figures meant that the uses building information modeling in minimization of design errors.

On the question of whether BIM encourages Stakeholder collaboration for design efficiency, the study found that 35 (30.4%) of the respondents strongly agreed, 48 (41.7%) of them agreed, 16 (13.9%) disagreed while 15 (13%) of the respondents were neutral. These results summed up to a mean of 3.87 and standard deviation of 1.03. It was therefore concluded that BIM encourages stakeholder collaboration for design efficiency. The study also sought to find out if the county design clash detection is boosted in a multi-discipline project by use of BIM. The results as shown in Table indicate that the question had a mean of 4.21 and standard deviation of 1.064. Of the respondents, 62 (53.9%) strongly agreed that the county design clash detection is boosted in a multi-discipline project by use of BIM, 32 (27.8%) agreed, 17 (14.8%) disagreed and 4 (3.5%) were uncertain concerning this question.

The research further sought to find out whether project design complexity is simplified in a BIM environment. The research respondents were asked to state the degree to which they concurred with this statement above. Of the total respondents, 31 (27%) strongly agreed, 50 (43.5%) agreed, 7 (6.1%) strongly disagreed while 27(23.5%) of them were neutral. These results summed up to a mean of 3.85 and standard deviation of 1.019, meaning that project design complexity is simplified in a BIM environment. The study further enquired from the respondents whether design variations are easily detected, and change orders managed. The results revealed that 33 (28.7%) of the respondents strongly agreed, 59 (51.3%) of them agreed, 6 (5.2%) disagreed and 16 (13.9%) strongly disagreed. These statistics summed up to a mean of 3.76 and standard deviation of 1.308, meaning that design variations are easily detected, and change orders managed.

The research further sought to establish if BIM in project design ensures uniformity of design standards for all stakeholders. The respondents were thus asked to respond accordingly. Of the respondents, 18 (15.7%) strongly agreed, 58 (50.4%) agreed, 8 (7%) disagreed and 31 (27%) of them were neutral. The item realized a mean of 3.75 and standard deviation of 0.804, revealing that BIM in project design ensures uniformity of design standards for all stakeholders. In general, the results on BIM in project design garnered a mean of 3.8996 and standard deviation of 0.79982. These figures implied that the respondents were agreeable on most of the items. On the other hand, the standard deviation indicated that there was less variation in their responses.

6.2 BIM in Project Estimation:

The study sought to find out if BIM help in accuracy in cost estimation and budget preparation. From the findings, 16(13.9%) of the respondents strongly agreed that BIM help in accuracy in cost estimation and budget preparation, 68(59.1%) of them agreed while 31(27%) of the respondents were neutral. The mean value of 3.87 was a confirmation that BIM help in accuracy in cost estimation and budget preparation.

The study also sought to establish if BIM aids accuracy in project execution time estimation. The respondents were asked to respond accordingly, and 32(27.8%) of them strongly agreed, 28(24.3%) agreed, 1(0.9%) disagreed and 54(47%) of the respondents were neutral. The item realized a mean of 3.79 and standard deviation of 0.863, implying that BIM aids accuracy in project execution time estimation. Besides, the study sought to find out whether or not the county uses BIM in Material estimation which closely reflect actual materials used at project termination. The respondents were requested for their opinion, and the results were such that 16(13.9%) of the respondents strongly agreed, 27(23.5%) of them agreed, 21(18.3%) of them disagreed while 51(44.3%) of the respondents were neutral. The results summed up to a mean of 3.33 and standard deviation of 0.934, an indication that there was no definite answer over whether or not the county uses BIM in Material estimation which closely reflect actual materials used at project termination.

The research further sought to ascertain whether or not the use of BIM reduces resource wastage. The results on this item revealed that 37(32.2%) of the respondents strongly agreed, 59(51.3%) of them agreed while 19(16.5%) of the respondents were neutral. This summed up to a mean of 4.16 and standard deviation of 0.683. In general, the results on BIM in project estimation yielded a mean of 3.8094 and standard deviation of 0.65213. These figures suggested that the respondents were agreeable on most items on BIM in project estimation. The standard deviation further indicates that there were fewer variations in the responses to the items on this research question.

6.3 BIM in Project Scheduling:

Regarding whether or not the county uses BIM in resources allocation in all project stages, 8(7%) of the respondents strongly agreed, 43(37.4%) of them agreed, 46(40%) disagreed while 18(15.7%) of the respondents were neutral. These results summed up to a mean of 3.11 and standard deviation of 1.024, meaning that the county makes use of BIM in resource allocation in all project stages. The respondents were further asked to ascertain whether the county projects use BIM to create a project scheduling pie charts and bar charts. The results showed that 3(2.6%) of the respondents strongly agreed, 31(27%) of the respondents agreed, 10(8.7%) of them disagreed, 30(26.1%) strongly disagreed while 41(35.7%) of the respondents were neutral on this item. The results summed up to a mean of 2.71 and a standard deviation of 1.198, suggesting that the county rarely uses BIM to create a project scheduling pie charts and bar charts.

The study also sought to find out if the county employs BIM to create work-breakdown structure in their projects. Results indicated that 26(22.6%) of the respondents strongly agreed, 30(26.1%) of them agreed, 20(17.4%) disagreed, 17(14.8%) strongly disagreed while 22(19.1%) of the respondents were neutral. The results summed up to a mean of 3.24 and standard deviation of 1.374, indicating that the county employs BIM to create work-breakdown structure in their projects on rare occasions. Moreover, the study sought to establish if the county utilizes BIM in adding and assigning activities and resources. The results from the study indicated that 14(12.2%) of the respondents strongly agreed, 34(29.6%) agreed, 6(5.2%) disagreed and 60(52.2%) of the respondents were neutral. The item reported a mean of 3.47, meaning that the county utilizes BIM in adding and assigning activities and resources.

Furthermore, to ascertain if the county uses BIM in assign responsible managers to work-breakdown structure elements in projects, 3(2.6%) of the respondents strongly agreed,31 (27%) agreed, 41 (35.7%) were neutral,10(8.7%) disagreed and 30(26.1%) strongly disagreed that the county uses BIM in assign responsible managers to work-breakdown structure elements in projects. Finally, 43(37.4%) of the respondents agreed that the county uses BIM in generating project summary reports, 8 (7%) strongly agreed, 18 (15.7%) were neutral while 46 (40%) disagreed that the county uses BIM in generating project summary reports

6.4 BIM in information asymmetry:

The study sought to find out if the county uses BIMs to monitor and evaluate county projects. From the results, 39(33.9%) of the respondents strongly agreed that the county uses BIMs to monitor and assess county projects, 32(27.8%) of them agreed, 1(0.9%) disagreed while 43(37.4%) of the respondents were neutral.

To establish if BIM helps in project control systems, the respondents were asked to respond accordingly. In total, 10(8.7%) of the respondents strongly agreed, 47(40.9%) of them agreed, 21(18.3%) disagreed, and 30(26.1%) of the respondents were neutral. The item realized a mean of 3.28 and standard deviation of 1.056, revealing that it was unclear whether BIM helps in project control systems. Besides, the study sought to find out if all project milestones are tracked and stored in BIM. Therefore, respondents were requested to give their opinions. From the results, 29(25.2%) of the respondents strongly agreed, 38(33%) of them agreed, 8(7%) of them disagreed while 40(34.8%) of the respondents were neutral. The results summed up to a mean of 3.77 and standard deviation of 0.911, an indication that all project milestones are tracked and stored in BIM.

Also, the study sought to find out whether there is a regular check of input activities by uses BIM. Results indicated that 26(22.6%) of the respondents agreed, 17(14.8%) of them were neutral, 59(51.3%) disagreed, and 13(11.3%) of the respondents strongly disagreed. The results culminated in a mean of 3.49 and standard deviation of 0.968, indicating that there is a regular check of input activities by uses BIM. Generally, the results on BIM in project information asymmetry generated a mean of 3.6271 and standard deviation of 0.84517. The results suggested that the respondents were agreeable with most of the items. Moreover, there were minimal variations in their responses.

6.5 Project implementation success:

About whether projects implemented meet their operational performance goals, 29(25.2%) of the respondents strongly agreed that projects implemented meet their operational performance goals, 49(42.6%) agreed, 7(6.1%) strongly disagreed and 8(7%) of the respondents were neutral. The item reported a mean of 3.62 and a standard deviation of 1.225. This indicated that projects implemented meet their operational performance goals. Moreover, the study sought respondents' views on whether projects stay within set out budget limits. The results revealed that 22(19.1%) of the respondents strongly agreed that projects stay within set out budget limits, 75(65.2%) of them agreed, 6(5.2%) disagreed, 7(6.1%) strongly disagreed while 5(4.3%) of the respondents were neutral. The results summed up to a mean of 3.86 and standard deviation of 0.99. This implied that projects stay within set out budget limits.

The study also sought to find out if projects meet their technical or social performance goals. Therefore, the respondents were requested to give their opinions, and from the results, 12(10.4%) of the respondents strongly agreed, 43(37.4%) of them agreed, 29(25.2%) of them disagreed while 23(20%) of the respondents were neutral. The results generated a mean of 3.19 and standard deviation of 1.139. These scores indicated that it was unclear whether or not projects meet their technical or social performance goals. The research further sought to ascertain whether projects implemented meet their schedule objectives. The results showed that 33(28.7%) of the respondents strongly agreed, 31(27%) of them agreed, 6(5.2%) disagreed, 23(20%) strongly disagreed while 22(19.1%) of them were neutral. This summed up to a mean of 3.39 and standard deviation of 1.461. Furthermore, the research sought to find out if project results meet stakeholders' expectations. The respondents were asked to give their views on this issue. The results indicated that 25(21.7%) of the respondents strongly agreed, 57(49.6%) of them agreed, 16(13.9%) strongly disagreed while 17(14.8%) of the respondents were neutral. The results summed up to a mean of 3.65 and standard deviation of 1.229, meaning that project results meet stakeholders' expectations.

The study further sought to establish whether programs implemented reflect counties' development strategy. The respondents were requested to give their opinions, and the results showed that 25(21.7%) of the respondents agreed while 66(57.4%) of the respondents were neutral. The results summed up to a mean of 3.8 and standard deviation of 1.01. The study also sought to find out if most of the projects implemented provide good returns. The research results indicated that 10(8.7%) of the respondents strongly agreed, 69(60%) of them agreed, 8(7%) disagreed while 28(24.3%) of the respondents were neutral. The results summed up to a mean of 3.7 and standard deviation of 0.725, indicating that most of the projects implemented provide good returns

6.6 Correlation Results:

Pearson correlation results of the dependent and independent variables. The findings revealed that BIM in project design was positively and significantly correlated with project implementation ($r = 0.741$ $\rho<0.01$). Further, BIM in project estimation was positively and significantly correlated with project implementation ($r = 0.629$, $\rho<0.01$). Similarly, BIM in project scheduling was positively correlated with project implementation ($r = 0.792$, $\rho<0.01$) and BIM in project information asymmetry was indicated to positively correlate with project implementation ($r = 0.776$, $\rho<0.01$). These findings imply that BIM in project design, estimation, and scheduling and information asymmetry influence project implementation.

6.7 Model summary:

Table 6.1 illustrates the model summary of multiple regression models. The results showed that all the four predictors (BIM in project design, BIM in project estimation, BIM in project scheduling and BIM in information asymmetry) explained 74.2 percent variation of project implementation (R squared=0.742).

Table 6.1 Model summary

R	R Square	Adjusted R Square	Std. The error of the Estimate
.861	0.742	0.732	0.43546
a Predictors: (Constant), BIM In Project Design, BIM In project estimation			

6.8 ANOVA Model:

The research findings in Table 6.2 indicate that the above-discussed coefficient of determination was significant as evidenced by F ratio of 78.897 with p-value 0.000 <0.05 (level of significance). Therefore, the model was fit to predict project implementation using BIM in project design, BIM in project estimation, BIM in project scheduling and BIM in project scheduling.

Table 6.2: ANOVA Model

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	59.843	4	14.961	78.897	.000b
Residual	20.858	110	0.19		
Total	80.701	114			
a Dependent Variable: project implementation					
b Predictors: (Constant), BIM In Project Design, BIM In project estimation , BIM In Project scheduling, BIM In Project information asymmetry					

7. CONCLUSION

In conclusion, the study has established that BIM project design significantly influences project implementation success. As such, for the county to minimize design errors and facilitate collaboration for design efficiency, it is crucial to sort the services of BIM project design. Moreover, the county design clash detection is boosted in a multi-discipline project, and the project design system is simplified such that there is uniformity of design standards for all stakeholders.

Furthermore, BIM project estimation significantly influences project implementation success. Consequently, it is relatively easier to make a change to the building model while observing how the changes impact on the total costs of the project. Also, there is accuracy in cost estimation and project execution. Besides, there is a reduction in resource wastage and ease in accessing benchmark estimates from database data.

Regarding project scheduling, the study established that the county makes use of BIM project scheduling in resource allocation at all the project stages. However, the county rarely uses BIM to create project scheduling pie charts and bar charts. As well, the county rarely employs BIM to develop work-breakdown structures in their projects, though it utilizes BIM in adding and assigning activities and resources. Moreover, the county uses BIM in generating project summary.

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