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IMPACT OF EMPLOYEES IN HUMAN CAPITAL DEVELOPMENT ON BIM INNOVATION IN SME FIRMS.

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Abstract- The Architecture, Engineering and Construction (AEC) industry is facing a paradigm shift in the adoption of Building Information Modelling (BIM). However, the shift to its adoption and implementation in the emerging markets has brought distortion in both the business processes and environment for Small and Medium Enterprises (SME architectural) in the industry. This is attributed to the lack of clear orientation in Human Capital Development of the firms. This paper identifies the different strategies concerning the development of the Employeess human capital; development. This is achieved by identifying how BIM adopters differ from non-adopters in the ways their Employees's Human capital development is considered. The study involve two step analysis; empirical enquiry to identify the various indicators of the Employees's human capital development and the analysis of its impact on BIM adoption. The empirical enquiry comprised of research framework and fieldwork data collection. The framework was used to collect data from the fieldwork. It involved a questionnaire survey with a sample of SME architectural firms in Nigeria. The survey involved administering questionnaires by hand to 351 firms within nine cities in Nigeria during September 2015. It yielded 228 completed questionnaires by the end of December 2015. Using regression analysis, the result indicates that, there are three critical indicator that determine the role of Employees in BIM innovation, these are; regular training, willingness to accept innovation and self-motivations.
Keywords– Building Information Modelling (BIM), Human Capital, Business Value, Small Medium Enterprise (SME), Architectural Firms, Nigeria.

1. INTRODUCTION

Employees in this context refer to any individuals within the SME architectural firm who are not within a top management position and whose activities and effort is relied upon to achieve the routine activities of the firm. Hence, Hayton (2005) and McGuirk et al (2015) provided evidence that the motivation and capabilities of individual employees through their qualities of education, intellect and cognitive abilities are related to higher levels of creativeness and openness to innovation. Also, McGuirk et al (2015) stressed that these qualities could contribute to the efficiency and success of the capability and motivation of human resource management practices oriented at promoting innovation. Shipton et al (2005) argued that sophisticated human resources management focuses on employees' exploratory learning through maximising their abilities to create, transfer and implement knowledge, and that this has been related to improvements in the innovation capabilities of firms. Andries & Czarnitzki (2014) stressed that involving and allowing individual employees to engage with innovation activities might allow for the discovery and exploitation of local knowledge, particularly when there are incentives in place that foster such discovery (Argote, 2012). Lichtenstein & Brush (2001) suggested that employees have the potential to contribute to a small firm's innovation process. Indeed, a study by Love et al (2014) showed that there is a significant percentage of top managers that affirm the potential of their employees in the innovation process. Thus, in this study, four indicators have been identified to form the variables or predictors in determining the motivation and capability of employees in SME architectural firms to innovate and these are; employees with regular training, shared innovative values, willingness to accept changes, and self-motivation.

As regards regular training, (Toner, 2011) stressed that there is a strong association between the on-job technical training of employees and a firm's ability to innovate. Romer (1990) added that the HC of a firm could be assessed through the cumulative effects of formal education and the on-the-job training of its employees. McGuirk et al (2015) suggested that a series of skills is required for innovation, which can include basic and digital age literacy, and academic and technical training skills. However, this emphasises that technical skills can be regarded as a requisite for innovation in the firm. This assertion is also advocated by Becker (2009) who, despite stating that HC is the measure of a firm's investment in its human resource, still suggested that schooling and training courses represent an investment in HC. According to Becker (2009), general training increases the productivity of employees. However, Mincer (1974) argued that schooling alone is not sufficient as a method of training, stressing that graduation from school is rather a preparatory stage of training. Hence, regular training can affect the innovation process in the firm.

With regard to employees' innovative values, Majchrzak et al (2004) suggested that the shared understanding and commitment of employees toward achieving the strategic goal and the firm's vision of innovation significantly affects the

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innovation capability of the firm. McGuirk et al (2015) also stressed their importance by arguing that a firm whose top managers effectively communicate and are committed to implementing these elements record significant success in their innovation capabilities.

Furthermore, with regard to their willingness to accept innovation, Lu & Sexton (2009) stressed that the more employees in a firm are motivated and open to new ideas, the more innovative and efficient their practices will be. Hence, they emphasised the importance of having employees who are willing to accept innovation. Santos-Rodrigues et al (2010) also confirmed that innovative behaviours, such as employees' willingness to accept new ideas and different ways of doing things, have an impact on the innovativeness of firms. McGuirk et al (2015) presented evidence that the willingness of employees to accept change significantly affects the success of innovation in firms. The study added that such willingness to change includes a commitment to increase the level of technology or computers involved in an employee's work; a willingness to accept change in the level of skills necessary to carry out their job, and increased responsibility among others.

With regard to the self-motivation of employees as a predictor of HC, McGuirk et al (2015) provided some evidence that employees' competencies, values, attitudes and skills are a sum of their self-motivation and a crucial factor in SME architectural firms' innovations. Hence, this can also affect the BIM adoption process. This is particularly true as BIM adoption is characterised as a knowledge absorption and creation process (Sexton & Barrett, 2004). Indeed, firms cannot create knowledge for themselves without the initiative of individual employees (McGuirk et al, 2015) . Firms must have people that know how to (and want to) select, integrate, share and enrich information to create understanding and true knowledge, and turn it into innovation. In that sense, apart from 'formal' competencies, like education, other personal characteristics, such as one's values, attitudes and skills, seem to be equally critical for BIM innovation success.

Hypotheses and Sub-Hypotheses: Motivation And Capabilities Of Employees

Thus, from the above discussion, the study formulated the following hypothesis for the empirical enquiry which is also illustrated in **Error! Reference source not found.**:

H31: The motivation and capabilities of the employees of SME architectural firms regarding innovation have a significant correlation with BBVC.

H30: The motivation and capabilities of the employees of SME architectural firms regarding innovation have no significant correlation with BBVC.

Sub-Hypotheses:

H3a: Firms that develop their innovation HC from employees with regular training are likely to succeed in BBVC.

H3b: Firms that develop their innovation HC from employees with shared innovative values are likely to succeed in BBVC.

H3c: Firms that develop their innovation HC from employees' willingness to accept innovation are likely to succeed in BBVC.

H3d: Firms that develop their innovation HC from employees with self-motivation are likely to succeed in BBVC.

2. RESEARCH FRAMEWORK

This section discusses the dependent variable of the study, which is BBVC. It starts by defining BIM from the business perspective, and the emergence of the term 'business value' in BIM. Subsequently, the study defines the term BBVC through the literature of IT business value and built its case from that field.

Vass (2015) suggested that most studies on measuring business value in the field focus on evaluating the value of IT. Others concentrate on determining suitable metrics or key performance indicators to measure and evaluate the effects of implementing IT, and in particular to measure any increased productivity from IT. This is also true in the case of current construction management and BIM research (Aranda-Mena et al, 2009; Barlish & Sullivan, 2012; Construction, 2014; Vass, 2014). For example, Curley (2004) explicitly states that, in order to measure the business value of IT in a firm, a maturity and capability metric is essential. This is also reiterated by Succar (2009) and Aranda-Mena et al (2009) who argued that generating business value through BIM is highly dependent on the individual capabilities of firms Similarly, McGraw-Hill (2009) suggested that numerous successful firms invest to make sure clients are aware of their BIM capabilities in order to create business value. All the above assertions point to the level of maturity and capability as essential in generating IT business value. (Curley, 2004; Kohli & Grover, 2008; Racheva et al, 2009).

3. BIM MATURITY AND CAPABILITY MODEL

Measurement of BIM success or maturity models in firms has well been established in the literature; it was early started by the National BIM Standard Capability Maturity Model (NBIMS-CMM), developed in the U.S. by the National Institute of Building Sciences (NIBS, 2007). NBIMS-CMM consists of eleven critical BIM measures, including business process, delivery method, data richness and information accuracy. It focuses only on information management and has been therefore criticised for not reflecting the diverse facets of BIM. Critics have also questioned its usefulness and usability due to its structural limitations (Succar, 2010). So profound and powerful these critics were and resulted in the introduction of new models that tried to build on NBIM-CMM and provide more optimised models. However, following the success of the UK BIM Task Group over the past years in defining and implementing BIM Level 2 within Government Departments. The emergence of new models seeks better ways of measuring BIM. Frameworks such as the BIM Maturity Matrix (Succar, 2010), the Virtual Design and Construction (VDC) Scorecard (Kam, 2015) and the BIM Maturity Measure (BIMMM)

(Ammar et. al, 2017), have been designed to improve previous models. They have supplemented past measures with diverse areas of measurement that represent much broader dimensions of BIM e.g. policies, technologies and processes. Individually and collectively, coexisting AMs have contributed to the growing body of literature that examines BIM use.
In order to develop the measure for BBVC based on these various models and efforts, it is important to reflect on all the existing maturity models/indices of maturity and capability concerning the BIM process.
Numerous models contribute to the development of viable BIM maturity and capability models. Among them are; Control Objects for Information and Related Technology, CMMI (Capability Maturity Model Integration), CSCMM (Construction Supply Chain Maturity Model), I-CMM (Interactive Capability Maturity Model), Knowledge Retention Maturity Levels, LESAT (Lean Enterprise Self-Assessment Tool), P3M3 (Portfolio, Programme and Project Management Maturity Model), PCMM® (People Capability Maturity Model), (PM)² (Project Management Process Maturity Model), SPICE (Standardised Process Improvement for Construction Enterprises), Supply Chain Management Process Maturity Model, and BPO (Business Process Orientation Maturity Model). These models as listed in (Succar et al, 2012) were studied by Kori & Kiviniemi (2015) with regard to BIM in Nigeria, and the outcome was that most of these models were broad in approach and could collectively form a basis for a range of BIM capabilities. However, Succar (2009) suggested there is not enough differentiation between the notion of capability and that of maturity. Hence Succar (2009) defines 'BIM maturity' as, "the quality, repeatability and degree of excellence within a BIM capability and developed the BIM Maturity Matrix". Succar described BIM capabilities in three stages:
Object-based modelling;
Model-based collaboration; and
Network-based integration.
Barlish & Sullivan (2012) highlighted that it is the extent of an organisation's performance or ability within a particular stage that is measured to determine their BIM maturity. This is gauged according to the five maturity levels shown in **Error! Reference source not found.**The BIM maturity level at Stage 1, for example, indicated an organisation performing testing or pilot projects to determine the benefits of BIM (Barlish & Sullivan, 2012); this is the first stage (object-based modelling) and within that phase they are at an 'ad-hoc' or 'defined' maturity level, working for more optimisation through increasing testing. Furthermore, the organisation's level of BIM maturity can be accessed via general objectives within a level similar to **Error! Reference source not found.**Figure12: The BIM Maturity Map by Bew & Richards (2008) in BIM Overlay to the RIBA Outline Plan of Work (Sinclair, 2012), or matrix of competencies, is similar to Building SMART Alliance's BIM Capability Maturity Model. Organisations' varying levels of maturity should be taken into consideration when comparing organisations' BIM business cases.

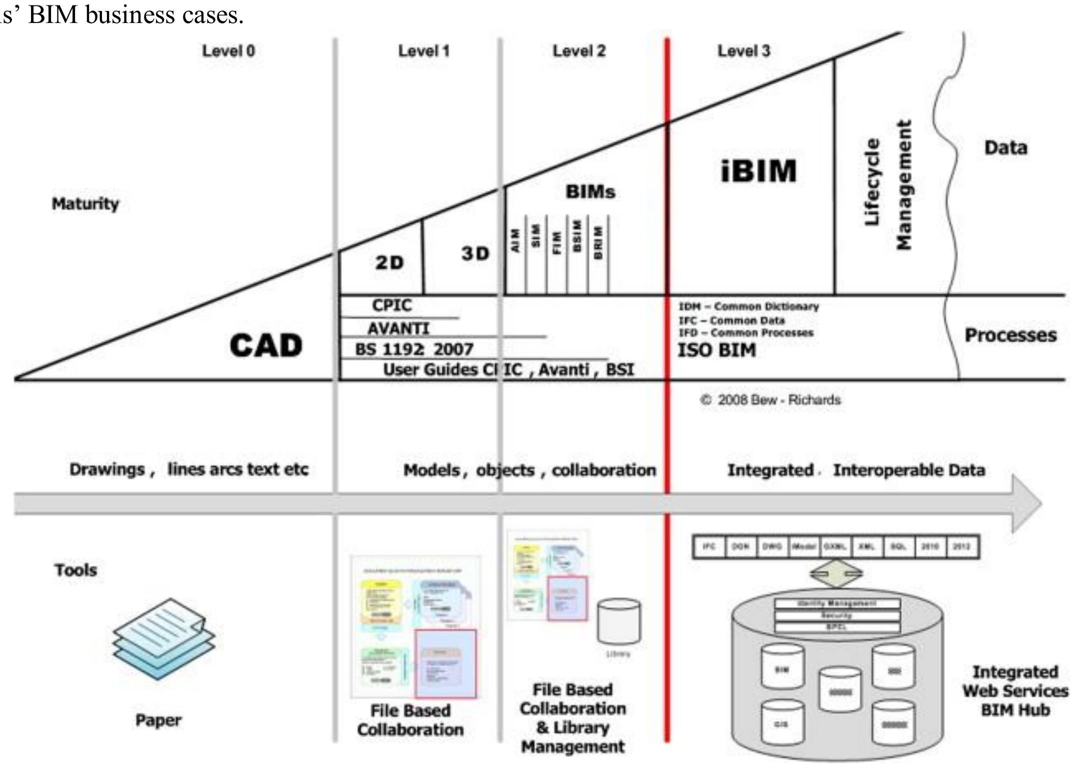

Figure 1: BIM Maturity Map (Bew & Richards, 2008)

Consequently, in accordance with the BIM Maturity map by Bew & Richards (2008) having identified the BIM fields, Succar (2009) further developed five stages which delineate capability milestones. Succar (2009) describes BIM capability as the basic ability to perform a task, deliver a service, or generate a product. BIM capability stages (or BIM stages) define the major milestones for achievement by teams and organisations as they adopt BIM technologies and concepts. BIM stages identify a fixed starting point (the status before BIM implementation), three fixed BIM stages, and a variable ending point, which allows for unforeseen future advancements in technology. The following is a list and description of each of the five stages developed in accordance with Succar & Kassem (2015) BIM Maturity Matrix, which is subsequently used as the baseline in developing the measure of BBVC for this study.

Pre-BIM status: Disjointed Project Delivery : The construction industry is characterised by adversarial relationships where contractual arrangements encourage risk-avoidance and risk-shedding. Much dependence is placed on 2D documentation to describe a 3D reality. Even when some 3D visualisations are generated, these are often disjointed and reliant on two-dimensional documentation and detailing. Quantities, cost estimates and specifications are neither derived from the visualisation model nor linked to documentation. Similarly, collaborative practices between stakeholders are not prioritised and workflow is linear and asynchronous. Under pre-BIM conditions, the industry suffers from low investment in technology and a lack of interoperability.

BIM Stage 1 Object-Based Modelling : Collaborative practices at Stage 1 are similar to the pre-BIM status and there are no significant model-based interchanges between different disciplines. Data exchanges between project stakeholders are uni-directional and communications continue to be asynchronous and disjointed. As only minor process changes occur at Stage 1, pre-BIM contractual relations, risk allocations and organisational behaviour persist. However, the semantic nature of object-based models and their ‘hunger’ for early and detailed resolutions of design and construction challenges encourage the ‘fast-tracking of project lifecycle phases - when a project is still executed in a phased manner yet design and construction activities are overlapped to save time.

BIM Stage 2: Model-Based Collaboration : Although communication between BIM players continue to be asynchronous, pre-BIM demarcation lines separating roles, disciplines and lifecycle phases start to fade. Some contractual amendments become necessary as model-based interchanges augment and start replacing document-based workflows. Stage 2 also alters the granularity of modelling performed at each lifecycle phase as higher-detail construction models move forward and replace (partially or fully) lower-detail design models.

BIM Stage 3: Network-Based Integration : At this capability stage, semantically-rich integrated models are created, shared and maintained collaboratively across project lifecycle phases. This integration can be achieved through 'model server' technologies (using proprietary, open or non-proprietary formats), single-integrated/distributed-federated databases, Cloud Computing or SaaS (Software as a Service). BIM Stage 3 models become interdisciplinary nD models allowing complex analyses at early stages of virtual design and construction. At this stage, model deliverables extend beyond semantic object properties to include business intelligence, lean construction principles, green policies and whole lifecycle costing. Collaborative work now ‘spirals iteratively’ around an extensive, unified and shareable data model. From a process perspective, a synchronous interchange of the model and document-based data cause project lifecycle phases to overlap extensively forming a phase-less process.

Integrated Project Delivery: Interdependent, Real-Time Models : This is the most suitable stage representing a long-term vision of BIM as an amalgamation of domain technologies, processes and policies. The term is generic enough and potentially more readily understandable by industry than ‘Fully Integrated and Automated Technology’, Integrated Design Solutions, or ‘nD Modelling, as three prominent examples. The selection of Integrated Project Delivery (IPD) as the goal of BIM implementation is not to the exclusion of other visions appearing under different names. On the contrary, the path from Pre-BIM (a fixed starting point), passing through three well-defined stages towards a loosely defined IPD is an attempt to include all pertinent BIM visions irrespective of their originating sources.

Similarly, Aranda-Mena et al (2009) developed a model based on the Val IT approach (ITGI, 2006) identified three layers of capability:

Technical capability: the specific technological capabilities delivered by the programme.

Operational capability: the operational capabilities that are supported by the technological capabilities.

Business capability: the overall business capabilities enabled by the operational capabilities.

The discussion above provided a baseline for shaping an appropriate model that could fit the context of this study. However, because the study deals with SME architectural firms in a Nigerian context, there may be some layers and elements that might need to be re-evaluated and contextualised. Hence, the following discussion will focus on the contextualisation of the model.

4. METHODOLOGY

The study involves two-step analysis; empirical enquiry to identify the various indicators of the Employees’s human capital development and the analysis of its impact on BIM adoption. The empirical enquiry comprised of research framework and fieldwork data collection. The framework comprises of two main variables, these are; The independent variables which involved the Employees’s indicators and the dependent variables which is the measure of BIM Business Value, the framework was used to collect data from the fieldwork. It involved a questionnaire survey with a sample of SME architectural firms in Nigeria. The survey involved administering questionnaires by hand to 351 firms within nine cities in Nigeria during September 2015. It yielded 228 completed questionnaires by the end of December 2015. The survey data enable the assessment of the framework using multiple regression analysis. The regression analysis was done based on two-step analysis; first through investigating the correlation between the main variables of the Employees component and the

BIM Business value creation which is a combination of the four indicators, secondly, the effects of each of the four indicators on the BIM business Value creation. The outcome provides with the Relative Weighting Value (RWV) of each of the four indicators on the BIM Business Value Creation in the SME firms.

5. ANALYSIS

This section discusses the data analysis and results of the study. In other to investigate the relationship in the first step of the analysis, a multiple linear regression and correlation analysis was conducted to assess whether the independent variables predict the dependent variable (criterion). The multiple linear regression assesses the relationship between a set of dichotomous, or ordinal, or interval/ratio predictor variables on an interval/ratio criterion variable (Solutions, 2013) . Hence, the following regression equation (main effects model) was used for each component as a regression model:

y = b0 + b1x1 + b2x2 + ……. + bnxn + e

Where, y = estimated dependent variable (BBVC), e = constant (which includes the error term), b = regression coefficients and x = each independent variable (the individual indicators (predictors) of the component), n = number of indicators under a component.

A standard multiple linear regression, called 'the Enter' method, was used for the SPSS analysis. In this method, the user enters all independent variables (the four indicators of the Employees's role) simultaneously into the model. Variables were evaluated by what they add to the prediction of the dependent variable, which is different from the predictability afforded by the other predictors in the model (Nach, 2009) .

In order to test the component level hypotheses in terms of whether there is a significant linear relationship between the individual components in the theoretical model and the dependent variables, the F-test was used. It involved testing whether the set of the independent variables (indicators) collectively predicts the dependent variable for that particular component. The 'R-squared' multiple correlation coefficients of determination were also reported and used to determine how much variance in the dependent variable can be accounted for by the set of the independent variables. The t-test was used to determine the significance of each of the indicators and beta coefficients were used to determine the magnitude of prediction for each indicator variable. For significant predictors, every one-unit increase in the predictor, meant the dependent variable will increase or decrease the number of unstandardized beta coefficients (Statistics Solutions, 2013).

This section presents the analysis of the relationship between motivation and capability of an Employees in SME architectural firms and the BBVC. Table 4 lists the variables of the Employees components.

Table 1: Variables of the employee's component

Independent Variables			Dependent Variables
Component Level	The motivation and capability of employees		BIM Business Value Creation (BBVC)
Indicators Level	1	Employees with regular training	
	2	Employees with shared innovative value	
	3	Employees with willingness to accept innovation	
	4	Employees with self-motivations	

The Regression Analysis

A multiple regression analysis was conducted to investigate if the motivation and capabilities of employees toward innovation in SME architectural firms have a significant correlation with success in BIM adoption. This involved analysing the effect of four indicators concerning employees in predicting the success in the BIM adoption. Preliminary analysis shows that all assumptions are valid and the potential variables of the indicators are accepted to carry out the multiple regression analysis.

Table 2: Model summary for the employee's component

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.764a	.584	.577	.92629

a. Predictors: (Constant), Employees with self-motivations, Employees with regular training, Employees with willingness to accept innovation, Employees with shared innovative value

Table 3 shows the multiple linear regression model summary and overall fit statistics. The table shows that the adjusted R^2 of the model is 0.577 with the $R^2 = 0.584$, which means that the linear regression explains 58.4% of the variance in the data.

Table 3: Anova test for employees component

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	268.927	4	67.232	78.358	.000b

Residual	191.336	223	.858		
Total	460.263	227			

a Dependent Variable: BBVC

b. Predictors: (Constant), Employees with self-motivation, Employees with regular training, Employees with willingness to accept innovation, Employees with shared innovative value

Table 14 shows the linear regression's F-test, which has the null hypothesis H30 that there is no linear relationship between the dependent variables and independent variables at the component level (in other words $R^2=0$). The F-test show F value of 78.358 with highly significant P-value; thus, the study can assume that the null hypothesis H30 is rejected; hence, H31 is accepted, which means, at the components level, there is a significant linear relationship between the motivation and capability of the employees in SME architectural firms and BBVC. However, to determine the direct effect, it is essential to conduct further analysis at the indicator level. Hence, the result of the analysis on the level of the indicator is presented in Table 15.

Table 4: Coefficient showing the linear regression estimates of all the indicators of the employee's components on BBVC

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.505	.177		2.844	.005
	Employees with regular training	.452	.090	.446	5.040	.000
	Employees with shared innovative value	.080	.094	.087	.842	.401
	Employees with willingness to accept innovation	.218	.098	.216	2.219	.027
	Employees with self-motivations	.525	.060	.524	8.697	.000

a. Dependent Variable: BBVC

Table 15 shows the multiple linear regression estimates of all the indicators, thus testing the four Sub-Hypotheses, H3a-H3d, including the intercept and the significance levels on the effect of each indicator on the IC of BBVC. The unstandardised coefficients' Beta (B) value indicates the extent of the effects for each of the independent variable on the dependent variable BBVC. The table shows that there is a significant positive effect on BBVC when firms rely on the motivation and capability of employees with regular training, where there is a willingness to accept innovation and concerning employees' self-motivation. However, the capability of employees to share their innovative value with the firm does not significantly predict the success level of BIM adoption.

6. CONCLUSION

The development of the HC of SME architectural firms in the AEC industry is essential to the business process of BIM adoption; it also helps firms to evaluate their capability for innovation. The development of this capital involved the motivation and capability of all the human resource of the firm from the top management, the Employees and the employees to all work simultaneously in creating BBVC. For example, while the Employees's education and experiences add major value in the operational aspect of the BIM, there is a need for the firm to consider their job satisfaction, particularly concerning their work-life balance, which is believed to acknowledge and respond to the Employees's working and personal needs and thus support their performance of their duties. Nevertheless, the top manager needs to ensure the continued understanding of the strategic need for planning in the BIM environment and encourage innovativeness and teamwork in settings and to implement strategic plans. Furthermore, education and training are identified as important elements of BIM implementation due to the process and technological changes they bring to an organisation. Hence, there is a need for regular training for general employees on the necessity of innovativeness as well as on the way BIM changes the processes of a firm. However, this should be done sensitively rather than as a directive as the need for positive self-motivation is critical for the success of the firm.

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