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ORGANISATIONAL READINESS OF BUILDING INFORMATION MODELLING IMPLEMENTATION: ARCHITECTURAL PRACTICES

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Graphical abstract

BIM Implementation Requirements	Severity Index	Rank
B10. Interoperability of BIM	0.3731	1
A03. Selection of BIM tools	0.4285	2
B03. Employment of pilot project	0.4416	3
A06. Risks management	0.4418	4
B06. Development of guidelines and standards	0.4435	5
C05. Conduction of series of awareness programme	0.4579	6
A02. BIM execution plan	0.4816	7
C09. Supportive work environment	0.4834	8
D03. Compatibility of BIM software vendors	0.5340	9
C07. Learning by doing approach	0.5880	10

Abstract

Building Information Modelling (BIM) has been emerged to streamline the construction process by addressing interdisciplinary inefficiencies that have been rooted in the industry over the decades. However, Malaysia construction industry is having barriers and difficulties in BIM adoption as there is no clear guidance and best practices in BIM implementation that can be learnt by them. The purpose of this research is to increase the awareness of BIM implementation towards enhancing the efficiency and productivity of architecture firms. BIM implementation requirements which cover management, process, people and technology were investigated through a total of 285 structured questionnaire surveys that distributed to professional or/and graduate architects at management and operational level. The overall severity of BIM implementation requirements were then established and ranked in conjunction with their perceived levels of importance and frequency of occurrence. Results indicate that the current low BIM status denominated among architectural practices in Malaysian construction industry. Predominantly attributed to the interoperability of BIM, selection of BIM tools, employment of pilot project, risks management and development of guidelines and standards that categorised under the management and process.

Keywords: Organizational readiness, architectural firms, implementation

Abstrak

Permodel Maklumat Bangunan (BIM) diperkenalkan untuk menyelaraskan proses pembinaan dengan menangani ketidakcekapan antara disiplin yang telah berakar umbi dalam industri ini sejak beberapa dekad lalu. Walau bagaimanapun, industri pembinaan Malaysia mempunyai halangan dan kesukaran dalam penggunaan BIM kerana tidak ada panduan yang jelas dan amalan terbaik dalam pelaksanaan BIM yang boleh dipelajari mereka. Tujuan kajian ini adalah untuk meningkatkan kesedaran mengenai pelaksanaan BIM kearah meningkatkan kecekapan dan produktiviti firma seni bina. Keperluan pelaksanaan BIM meliputi pengurusan, proses, kakitangan dan teknologi telah dikenalpasti melalui sejumlah 285 kajian soal selidik berstruktur diedarkan kepada profesional atau/dan graduan arkitek di peringkat pengurusan dan operasi. Indeks keterukan keseluruhan keperluan pelaksanaan BIM kemudiannya dibangunkan dan kedudukan indeks kepentingan dan kekerapan dilakukan. Keputusan menunjukkan bahawa status BIM semasa yang rendah mendominasi amalan seni bina dalam industri pembinaan di Malaysia. Kebanyakannya disebabkan oleh operasi bersama dalam BIM, pemilihan alat BIM, melaksanakan projek perintis, pengurusan dan pembangunan garis panduan dan piawaian yang dikategorikan di bawah pengurusan dan proses risiko.

Kata kunci: Kesediaan organisasi, firma-firma arkitek, perlaksanaan

1.0 INTRODUCTION

The Construction Industry is one of the major contributors to the aggregate economy as perceived from its revenue generation, capital formation, and employment creation which support the GDP as well as socioeconomic development of Malaysia. However, it has been facing challenges in increasing productivity, efficiency, quality and value in order to achieve sustainability and clients satisfactory. Some of the problems associated with the industry are cost overrun, delay, conflict and eventual lawsuit which caused by error and miscommunication during the project delivery process [1]. The industry that characterized by multidisciplinary nature whereby the exchange of information among parties remains fragmented as it frequently depends on paper-based modes communication that involves a lot of documents and drawings. In addition, inappropriate sequence of works that fail to incorporate essential details and energy considerations early at the design phase often result in compromise to the original design with decreased efficiency and quality. In Malaysian context, the Construction Industry Development Board (CIDB) was established in the year of 1994 under 10th Malaysia Plan which aims to develop the capacity and capabilities of the industry through professionalism, innovation and knowledge. Some of the responsibilities allocated to CIDB are recommendation and coordination on the industry related matters including registration of contractor, improvement of knowledge, training, safety, and education [2].

The CIDB has taken initiatives to increase competiveness of the industry by implementing various master plans latest by Construction Industry Master Plan (CIMP) 2006-2015, CIMP aim to correct the weaknesses and improve performance and image of Malaysian construction industry with application of seven strategic thrust. The first strategic thrust promoting integration among stakeholders to enhance productivity and efficiency while the sixth strategic thrust emphasized on the leverage the power of ICT for productive effective management apart from construction market expansion [3]. These are aligned with the functional aspects of BIM which is recognized as panacea to interdisciplinary inefficiencies inherited in the construction industry that is fragmented, complicated, risky and uncertain by nature [4, 5]. Nevertheless, BIM implementation in Malaysia is still low and stagnant due to deficiency of BIM related knowledge, skills and majority of the key players of Malaysian construction industry do not know how, when and what to start. The industry is having barriers and difficulties in BIM adoption as there is no clear guidance and best practices in BIM implementation that can be learnt from and followed in order to increase their BIM capacity and competency. Thus, this paper objective is to identify the level of organizational readiness prior to the BIM implementation by measuring its internal capabilities to embrace BIM successfully.

2.0 OVERVIEW OF BIM

2.1 Definition of BIM

There are number of perspectives in construction industry and academia regarding the constitution of BIM. According to [6] BIM is ambiguous term that can be interpreted in varying ways to represent a partial or holistic view of BIM philosophy by different professionals. BIM accompanied by creation of confusion at three different aspects as for some it is a software application while for others it is a process of designing and recording building information apart from being a new approach in improving the profession with adoption of new policies, contract and enhancement of relationship among stakeholders as affirmed by the empirical result from the research. According to [7] BIM can be defined as an advancement of CAD that provides linkages to all the components of a building as objects embedded with information. BIM also generalized as an encapsulate database that encourage the exchange of valuable information or data through utilization of ICT technologies. It can be further elaborated as lifecycle evaluation concept that seeks to integrate processes by creating and reusing consistent digital information produced by the stakeholders throughout the entire life cycle of a construction project [8].

2.2 BIM Implementation Approach

BIM implementation is a paradigm shift as it exerts great influences on every level of project delivery processes. It is not solely lies in changing of software application but more importantly is the social-cultural environment that provides the context for its implementation as advocated in social technical view of BIM implementation [9, 10]. Incremental change in term of work practices, staff skills, relations with client and participants of project implementation team as well as contractual arrangements are required in order to have successful BIM implementation [11]. Project team members are commonly equipped with different levels of BIM methodology knowledge. Thus, there will be a challenge in dealing with some barriers and obstacles of different nature. BIM implementation needs to be employed progressively and supported by the team, the management, and a cooperative owner.

2.2.1 Diagnosis

There are several main areas of discussion under the diagnosis stage. For the purpose of advancement, it is necessary to explore the current company

practice along with associated issues, challenges, problems that become the cause of the inefficiencies [4]. Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis can be used to assess the competitive advantages from BIM adoption.

2.2.2 Action Planning

The increased understanding of circumstances of the company with all the related elements has led to further attempt towards the action planning stage. It started with production of detail strategies concerning new business process and BIM adoption path [12]. Unorganized and duplication of project support information has caused difficulties in finding the definitive information and reduce the efficiency. The preparation and planning is fundamentally formulated by three factors which covered the financial restriction on speed of purchase, determine the appropriate pilot project, and rapidity of training and upskilling of staffs [4].

2.2.3 Taking Action

Pilot project was performed on past, current and future projects where future projects will be determined once the core training has been completed via piloting. Successful change management needs to incorporate adequate provision of training and information to all the stakeholders. Basically, training provided emphasized on four areas including basic operation skills, modelling standards, methodology of model construction, and collaboration with external parties [4, 13]. Continuous effort needs to be performed to develop the company's BIM standards and libraries for its own optimum practice [1].

2.2.4 Evaluation

BIM has many possibilities as can be seen in new invented 3D printing technology. Sustaining the BIM dialogue while processing new offerings; contribute to part of the enhancement of companywide capability [4].

2.3 Architectural Process

Architectural practice is becoming increasingly competitive internationally owing to globalization of economies, market, technology advancement, and demanding clients. Definition of an architectural practice embodies business which comprehends and fulfils the requirements of a client by translating those precedence and notions into the holistic buildable form [12]. Provision of sufficient construction information and site management may also form part of architectural services. Meanwhile, the extent of authority and level of deliverable development is defined in the contractual agreement. Architects are used to be the heaviest user of BIM and act as key player among professionals who exert significant influences in the Malaysian construction industry. But it is essential for them to counterbalance their creative desire in design with commercial constraint as expected by client who constantly request more in term of time, cost, and quality in reality. Therefore, reassess the architectural practice by tracking back to its key operations is critical to accommodate new ideas such as BIM in pursuing improvement.

3.0 METHODOLOGY

3.1 Data Collection

Survey questionnaires were developed based on previous literature review that capturing four key elements in assessing the organizational readiness for BIM implementation: Management, People, Process and Technology [14]. Respondents were constituted of professional or/and graduate architects at both management level and operational level due to their heavy dependence and usage of IT/ICT apart from its tendency to gain BIM related knowledge and experiences while developing and managing construction projects. Respondents were given opportunity to rate the elements of BIM implementation and its sub attributes in term of level of importance by choosing from a 5-points Likert Scale comprises of 5 – very important; 4 – important; 3 – neutral; 2 – not important; and 1 – very not important. Meanwhile, frequency of occurrence was designed based on an ordinal scale from H – High; M – Medium; and L – Low. This range of these scales is adequate as larger scale would not imposed any effects on the results due to the selected method of analysis [15]. Besides, respondents were also given opportunity to suggest to the list of BIM implementation requirements presented. For each item, the mean value of respondents' importance responses and frequency responses were calculated using a relative importance index (RII) and relative frequency index (RFI) as indicated in the following formulae:

$$RII = \frac{5n1 + 4n2 + 3n3 + 2n4 + n5}{5(n1 + n2 + n3 + n4 + n5)} \quad (1)$$

Where, n1 = Very Important, n2 = Important, n3 = Neutral, n4 = Not Important and n5 = Very Not Important.

$$RFI = \frac{3n1 + 2n2 + n3}{3(n1 + n2 + n3)} \quad (2)$$

Where, n1 = High, n2 = Medium, n3 = Low

Finally, the overall implication was represented by severity index, which is the multiplication of "relative importance Index" by "relative frequency Index". It was utilised to rank the overall severity of each of the

BIM implementation requirements for architectural practices which assist in formulating strategies to attain the desired BIM status. In all, 40 pre-identified BIM implementation requirements were successfully reviewed.

Severity Index = "Relative Importance Index" (RII) x "Relative Frequency index" (RFI) (3)

This study constraints the population frame to the states in Peninsular Malaysia with intense construction activities and development like Selangor, Wilayah Persekutuan Kuala Lumpur, Johor, and Pulau Pinang that are represented by the Gross Output percentage of 61.6%, 34.7%, 68.1%, and 44.7% respectively [16]. Therefore, this study collects data from organizational members of architectural firms in these states using simple random sampling method as suggested by [17]. The sample size is determined using an equation provided by [18]:

$$n=N/\ [1+\ (N\ x\ e^2))\quad (4)$$

Where, n = Number of samples, N = Number of population e = Sample deviation

The researcher refers to [18] and assumes 95% for confidence level and ±5% for confidence interval to calculate the sample size. Therefore, this study determines 285 architectural firms that were constituted of professional or/and graduate architects at management and operational level as the sample for the study from the population size of 1064 [17, 19]. The researcher self-administers and manages to obtain 96 responses within over approximately two to three months of being sent out, corresponding to response rates of 32%. However, only 91 questionnaires can be used and analysed (5 questionnaires are invalid) by using severity index.

4.0 RESULTS AND DISCUSSION

Results denoted out of the 40 BIM implementation requirements listed in the questionnaire, the ten most severe sub attributes categorized under the attributes of management (A), process (B), people (C) and technology (D) that causing ICT project failure and contribute to the low BIM status in the Malaysian construction industry are outlined as below. They were featured by high relative importance index in conjunction with low relative frequency index. Table 1 shows the severity index of BIM implementation requirements.

Table 1 Severity index of BIM implementation requirements

BIM Implementation Requirements	Importance Index	Frequency Index	Severity Index	Rank
B10. Interoperability of BIM	0.8480	0.4400	0.3731	1
A03. Selection of BIM tools	0.8240	0.5200	0.4285	2
B03. Employment of pilot project	0.8280	0.5333	0.4416	3
A06. Risks management	0.8720	0.5067	0.4418	4
B06. Development of guidelines and standards	0.8640	0.5133	0.4435	5
C05. Conduction of series of awareness programme	0.8080	0.5667	0.4579	6
A02. BIM execution plan	0.8600	0.5600	0.4816	7
C09. Supportive work environment	0.8240	0.5867	0.4834	8
D03. Compatibility of BIM software vendors	0.9000	0.5933	0.5340	9
C07. Learning by doing approach	0.9000	0.6533	0.5880	10

Note: A – Management; B – Process; C – People; D – Technology

4.1 Interoperability of BIM

In order to achieve optimal performance of BIM, commitment and cooperation among various stakeholders is needed. To date, interoperability of BIM among the multidisciplinary nature of Malaysian construction industry is still remain an unresolved issue where consistency of information exchange is questionable [4, 12]. Without the integrated project delivery (IPD), construction personnel confront problems pertaining to exchange and reading of BIM models especially between different BIM software vendors. Sharing and exchange of information made through usage of IFC causes partial data loss after the file conversion where subsequent editing, filtering and manipulation is required to make comprehensible and usable by recipient [4, 12, 20].

4.2 Selection of BIM tools

BIM implementation objectives was stressed to be aligned with business objectives in order to tackle and resolve some of the business problems and issues that impede the performance of the organisation. This can be accomplished through the appropriate selection of BIM tool that satisfy the priorities and intended competitive advantages as provided in business objectives of the organisation. Architectural firms need to abort the extensive practices of continual usage of product from the same vendor without further exploration. In fact, the selection of BIM tools need to be examined closely by reviewing the current work practices, IT system, company special features and priorities [4].

4.3 Employment of Pilot Project

Application of pilot project in small to medium scale is an ideal approach for BIM implementation at the

early stage. It can be a stepping stone used to increase BIM capacity and competency among employees through learning by doing approach in accordance to the statement of [21]. In addtiion, working together with BIM expert is imperative for the first-timers as it expedites the entire adaptation process and minimise the risks.

4.4 Risks Management

The current architecture market is still remains at the innovator phase and incapable to accommodate drastic change from CAD to BIM approach within the organisation context [1, 21]. Besides, huge investment capital in contrary with the high failure rate inherited in the ICT projects require long term plan with series of adoption cycles are to be taken to mitigate the risks. It is normally planned through four stages: Diagnosis, Action Planning, Taking Action and Evaluation with regular review on performance against the efficiency gains and objectives [4, 9, 13].

4.5 Development of Guidelines and Standards

The implementation and adoption of BIM in Malaysia is still remain stagnant as the construction players do not know how, when and what to start in the absence of BIM guidelines and standards at the national level [21]. Thus, architectural firms which often treated as the leader and driver for the whole construction scheme initiate to develop their own BIM implementation standards and guidelines that tailored and suited to the organisational needs developed in consultation to the BIM expertise as a temporary resolution in order to stay competitive through advancement of technology. However, all these versions resulted in confusion among construction players since the definition of level of development/details (LOD) is varied from one organisation to another organisation. In order to tackle this, CIDB has established National Steering Committee of BIM in July 2013 that responsible for the development of Malaysia BIM Roadmap in order to foster the construction industry towards broader adoption of BIM by 2020. In conjunction of that, the subcommittee of the BIM Roadmap which consists of relevant Government agencies, professional bodies, private sectors and academia was also formed to formulate a strategic plan for BIM implementation in Malaysia.

4.6 Conduction of Series of Awareness Programme

Many studies that exhibit the benefits of BIM were not carried out in the context of Malaysia have created doubts and confusion pertaining to the effectiveness of BIM utilisation. In addition, the scarcity of information, knowledge and highly skilled staffs in handling BIM technology have caused inability of the industry player to foresee and reap the benefits of BIM apart from the traumatic effect carried by the failure precedents of Industrialised Building System in the Malaysian construction industy even though with the full supports of the government of Malaysia [21]. Therefore, series of awareness programme is one of the approaches to stimulate widespread adoption and use of BIM in the construction projects.

4.7 BIM Execution Plan

Investment decision that frequently made through ad-hoc manner without adequate preparation has increased the IT/IS failure rate which leads to total abandonment of all development, maintenance of the implemented IT/IS [14]. Therefore, it is crucial to incorporate detailed execution plan in phases which allows for incremental transitional changes to facilitate the reduction of risks and resources in deal with resistance to change. However, the implementation of BIM is still low and stagnant due to deficiency of BIM related knowledge and skills among the key players of Malaysian construction industry. They are having barriers and difficulties in BIM adoption as there is no clear guidance and best practices in BIM implementation that can be learnt from and followed in order to increase their BIM capacity and competency [21].

4.8 Supportive Work Environment

Supportive work environment is urged to be fostered to work in complementary with the strategy deployment for successful BIM implementation among architectural practices. It is advisable to adopt a social-technical view of BIM implementation that considers both technology and the social-cultural environment that provides the context for its implementation [21]. Creation of supportive environment that reward performance while cutting down the resistance and negative stresses support an organisation's ability to enagage and retain diverse teams. This can be achieved through effective interpersonal communication, learning and development along with provision of adequate facilities and infrastructure

4.9 Compatibility of BIM Software Vendors

They [9] underlined the importance of exploration of BIM tools with respect to the current practice in association to the efficiency gain instead of blindly reusing and upgrading from the same product vendor as covered in diagnosis stage. Compatibility of BIM software with business and user requirement can be examined based on evaluation of BIM functionality against the types, sizes, requirements and specifications involved in the company construction projects. However, proficiency in AutoCAD resulted in pervasive usage of Revit Architecture that come from the same vendor, Autodesk family among the architectural practices due to familiarisation and avoidance of duplicate effort on the creation of information as project progressed.

4.10 Learning by Doing Approach

It is common that for employees to put aside things that have learnt after the completion of course if it is not compulsory. Thus, normative pressure is required to be created through championing behaviour as supported by [22] to drive the construction innovations since the desired competency can only be achieved with constant practices and hand-on experience. Learning by doing approach is adopted in real-world work context as it reduces disparity between knowledge and skills gained through formal training through practices which subsequently encourages well assimilation and embracement of changes within an organisation. Consistent BIM usage within a real project with stringent dateline and quality requirements facilitate the attainment of desired BIM status even without the presence of market demand.

5.0 CONCLUSION

Majority of the current IT/IS evaluation model are mainly post-investment measures which failed to address the readiness issues and resulted in project failure. The reliability analysis for assessing the severity of 40 BIM implementation requirements has been demonstrated. Results indicate that all the sub attributes used to measure the organizational readiness of BIM implementation are reliable (a = 0.934). The current low BIM status inherited among architectural practices in Malaysian construction industry is attributed to varying factors which predominantly constituted of interoperability of BIM, selection of BIM tools, employment of pilot project, risks management and development of guidelines and standards that categorized under the management and process. Meanwhile, people and technology aspect of BIM implementation requirements are comparably more advance as widely advocated in in the social-technical view of BIM implementation. These are accredited to the efforts from both governmental bodies and private sectors that practicing the "push and pull" elements.

References

[1] Eastman, C., Teicholz, P., Sacks, R., & Liston, K. 2008. *BIM Handbook: A Guide For Building Information Modelling For Owners, Managers, Designers, Engineers, And Contractors*. Hoboken, New Jersey: John Wiley & Sons, Inc.

[2] Kamal, E. M., Haron, S. H., Ulang, N. M., & Baharum, F. 2012. The Critical Review on the Malaysian Construction Industry. *Journal of Economics and Sustainable Development*. 3(13): 81-87.

[3] Sundaraj, G. 2007. The Way Forward: Construction Industry Master Plan 2006–2015. *Master Builders*.

[4] Arayici, Y., Egbu, C., & Coates, P. 2012. Building Information Modelling (BIM) Implementation And Remote Construction Projects: Issues, Challenges, And Critiques. *Journal of Information Technology in Construction*. 17: 75-92.

[5] Coates, P., Arayici, Y., Koskela, K., Kagioglou, M., Usher, C., & O'Reilly, K. 2010. The Key Performance Indicators Of The BIM Implementation Process.

[6] Aranda-Mena, G., Crawford, J., Chevez, A., & Froese, T. 2009. Building Information Modelling Demystified: Does It Make Business Sense To Adopt BIM? *International Journal of Managing Projects in Business*. 2(3): 419-434.

[7] Smith, D. K., & Tardif, M. 2009. *Building Information Modeling: A Strategic Implementation Guide For Architects, Engineers, Constructors, And Real Estate Asset Managers*. John Wiley & Sons.

[8] Arayici, Y., & Aouad, G. 2010. *Building Information Modelling (BIM) For Construction Lifecycle Management*. Nova Science Publishers.

[9] Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., & O'Reilly, K. 2011b. Technology Adoption In The BIM Implementation For Lean Architectural Practice. *Automation in Construction*. 20(2): 189-195.

[10] Azhar, S. 2011. Building Information Modeling (BIM): Trends, Benefits, Risks, And Challenges For The AEC Industry. *Leadership and Management in Engineering*. 11(3): 241-252.

[11] Migilinskas, D., Popov, V., Juocevicius, V., & Ustinovichius, L. 2013. The Benefits, Obstacles And Problems Of Practical BIM Implementation. *Procedia Engineering*. 57: 767-774.

[12] Coates, P., Arayici, Y., Koskela, L., Kagioglou, M., Usher, C., & O'Reilly, K. 2010. The Limitations Of BIM In The Architectural Process.

[13] Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., & O'Reilly, K. 2011a. BIM Adoption And Implementation For Architectural Practices. *Structural Survey*. 29(1): 7-25.

[14] Aziz, N. M., & Salleh, H. 2011. A Readiness Model For IT Investment In The Construction Industry. *African Journal of Business Management*. 5(7): 2524-2530.

[15] Kaming, P. F., Holt, G. D., Kometa, S. T., & Olomolaiye, P. O. 1998. Severity Diagnosis Of Productivity Problems—A Reliability Analysis. *International Journal of Project Management*. 16(2): 107-113.

[16] Department of Statistics Malaysia. 2012. *Economic Census 2011: Construction*. Kuala Lumpur: Department of Statistics Malaysia.

[17] Ramayah, T., Lim, C. Y., and Sulaiman, M. 2005. SME E-Readiness in Malaysia: Implications for Planning and Implementation. *Sasin Journal of Management*. 103-120.

[18] Yamane, T. 1967. *Statistics: An Introductory Analysis*. 2ed. Japan: Harper and Row Publishers, Incorporated.

[19] Sekaran, U. 2003. *Research Methods for Business: A Skill Building Approach*. Fourth ed. New York: John Wiley and Sons, Inc.

[20] Chien, K.-F., Wu, Z.-H., & Huang, S.-C. 2014. Identifying And Assessing Critical Risk Factors For BIM Projects: Empirical Study. *Automation in Construction*. 45(0): 1-15.

[21] Zahrizan, Z., Mohamed Ali, N., Tarmizi Haron, A., Marshall-Ponting, A., & Abd Hamid, Z. 2013. Exploring the Adoption Of Building Information Modelling (BIM) In The Malaysian Construction Industry: A Qualitative Approach. *International Journal of Research in Engineering and Technology*. 2(8): 384-395.

[22] Park, M., Nepal, M. P., & Dulaimi, M. F. 2004. Dynamic Modeling For Construction Innovation. *Journal of Management in Engineering*. 20(4): 170-177.