SYSTEMATIC APPROACH AND STRATEGIES FOR BUILDING INFORMATION MODELLING (BIM) ADOPTION IN THE JORDANIAN CONSTRUCTION INDUSTRY

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy of Science in Civil Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Kebanyakan negara menganggap industri pembinaan sebagai salah satu industri yang paling mencabar. Masalah-masalah utama yang dihadapi oleh kebanyakan syarikat pembinaan ini telah menyebabkan kadar penurunan prestasi dari semasa ke semasa yang semakin membimbangkan. Antara punca-punca yang menyebabkan hal ini berlaku termasuklah komunikasi yang tidak berkesan dan keadaan persekitaran yang kurang pendedahan berkaitan dengan sektor pembinaan. Di Jordan, industri pembinaan merupakan salah satu sektor ekonomi Jordan yang sangat penting. Pada tahun 2014, industri pembinaan menyumbang kira-kira 5.8 peratus kepada Keluaran Dalam Negara Kasar (KDNK) Jordan, yang mencatatkan peratusan lebih tinggi daripada sektor pertanian, elektrik dan air. Walaubagaimanapun, industri pembinaan di Jordan menghadapi isu kekurangan produktiviti disebabkan oleh kadar kelewatan yang berulangkali dalam menyelesaikan projek pembinaan dan lebihan kos pengeluaran. Di sebalik itu, terdapat banyak kajian mengenai penggunaan pemodelan maklumat bangunan (BIM) telah dijalankan di pelbagai negara termasuk Norway, Finland, Sweden, Jerman, Malaysia, Singapura, Perancis, Amerika Syarikat, Australia, dan United Kingdom di mana BIM telah membuktikan keupayaan untuk membangunkan integrasi maklumat, aliran proses perniagaan, produktiviti, dan mengurangkan kesulitan, ketidakpastian, konflik, dan perpecahan, antara satu sama lain. BIM adalah suatu pembaharuan terkini yang menjanjikan kemajuan dalam prosedur-prosedur pembinaan dan perkembangan teknologi dalam sektor AEC. Kajian ini bertujuan untuk menyediakan pembangunan sokongan bagi memastikan industri pembinaan di Jordan lebih maju dengan mengaplikasikan rangka kerja BIM. Setiap kontraktor, pemilik dan para perunding boleh menggunakan rangka kerja ini untuk menilai dan memahami tahap kesediaan dan keterbukaan mereka untuk mengaplikasikan BIM. Untuk mencapai objektif ini, kajian yang berkaitan telah dikelaskan secara komprehensif kepada dua konteks. Konteks yang pertama adalah dari segi industri pembinaan di Jordan, dalam meneroka kriteria terbaru bagi proses pembinaan dan cabaran berkaitan dengan tempat. Konteks yang kedua adalah dari segi teknologi BIM, konsep, aplikasi, pembangunan, keadaan penggunaan, dan proses yang paling tepat untuk memilih rangka kerja untuk penggunaan BIM dari kesemua sumber yang disenaraikan. Bagi menguji keberkesanan rangka kerja yang dipilih, penyelidikan menggunakan kaedah pendekatan kualitatif dan 15 temubual separa berstruktur telah dijalankan dengan beberapa organisasi pembinaan terkemuka dalam industri pembinaan di Jordan. Tiga tahap kesahihan dan kebolehpercayaan pemeriksaan dilakukan; Tahap pertama adalah bengkel secara berkumpulan di mana penyelidik membincangkan hasil keputusan dengan empat pakar dalam sektor pembinaan yang telah mencadangkan beberapa pengubahsuaian berkaitan komponen pengguna dalam rangka kerja teori, diikuti oleh tahap kedua kesahihan di mana 228 kajian secara soal selidik telah dijawab oleh organisasi-organisasi pembinaan yang terlibat. Hasil keputusan dianalisis menggunakan teknik pemodelan persamaan berstruktur di mana salah satu hipotesis ditolak dan pelarasan kedua mengenai komponen rangka kerja konseptual diambil alih. Pemeriksaan kesahihan yang terakhir telah dilakukan dengan membincangkan mengenai rangka kerja konseptual dengan tiga tonggak utama dalam bidang pembinaan di Jordan iaitu Kementerian Kerja Awam dan Perumahan, persatuan kontraktor pembinaan Jordan dan persatuan jurutera Jordan bagi mendapatkan hasil kesimpulan yang paling terbaik. Hasil penemuan menunjukkan bahawa penggunaan BIM di kalangan organisasi pembinaan di Jordan masih di peringkat pra-BIM di mana ia menghadapi banyak halangan dan cabaran seperti

kurangnya kesedaran berkaitan BIM, pusat latihan, pakar BIM, sokongan kerajaan, sumber kewangan dan ketahanan terhadap sesuatu perubahan. Kajian ini mencadangkan pengaplikasian rangka kerja BIM yang praktikal yang diakui dan disahkan oleh pakar utama dalam industri pembinaan di mana ia diharapkan boleh menyokong dan mempercepatkan operasi penggunaan BIM di kalangan industri pembinaan Jordan secara menyeluruh.

Selain itu, rangka kerja yang dicadangkan boleh digunakan sebagai penanda aras untuk mengukur kesediaan sesebuah organisasi untuk mengaplikasi teknologi BIM. Ia juga telah dirujuk dari kajian kesusasteraan terdahulu (dan kemudian disahkan oleh hasil temubual dan soal selidik) bahawa beberapa masalah yang dihadapi oleh industri pembinaan Jordan adalah: rekabentuk yang kurang baik, penjadualan dan perancangan yang tidak tersusun, perubahan arahan, kekurangan kakitangan teknikal yang kompetitif dan komunikasi yang tidak berkesan antara satu sama lain, yang membawa kepada isu-isu seperti masalah dana dan ketepatan masa yang dijanjikan. Kebanyakan peserta sebulat suara bersetuju mengenai penggunaan ITC dalam perniagaan mereka telah meningkatkan kecekapan mereka, menjimatkan masa dan mengurangkan kos. Walaubagaimanapun, hasil penemuan ini adalah berbeza daripada BIM. Kebanyakan pakar dari industri pembinaan menyedari mengenai kewujudan BIM tetapi tidak pernah mengaplikasikannya dalam amalan harian. Ada juga yang mengetahui kelebihan BIM, tetapi majoritinya menyatakan bahawa mereka tidak mempunyai pengetahuan tentang BIM. Dalam erti kata lain, kajian ini mendedahkan bahawa pakar-pakar yang mengetahui tentang BIM dalam lingkungan usia 30 hingga 49 tahun. Kebanyakan orang yang lebih berumur tidak berminat dalam mempelajari proses baru. Jurutera-jurutera baru juga tidak mepunyai pengetahuan mengenai BIM. Penyelidikan ini mencadangkan agar pendedahan hasil kajian ini boleh dijadikan sebagai rujukan dan piawaian terbaik dalam penerimaan BIM. Piawaian penerimaan ini dapat membantu sesebuah organisasi untuk mengiktiraf keupayaan BIM dan menilai kesediaan mereka untuk mengamalkan BIM. Di samping itu, kajian ini bertujuan untuk meningkatkan kesedaran semasa mengenai BIM dengan mencatatkan tahap kebimbangan berkaitan dengan BIM dan pengaplikasiannya dari sudut pandangan organisasi pembinaan. Selain itu, keputusan yang dibuat dalam kajian ini dapat membantu sektor industri bagi menyelesaikan masalah pengaplikasian BIM dalam situasi di Jordan. Akhir sekali, kajian ini dapat disimpulkan mempunyai kepentingan yang bermanfaat kepada sektor pembinaan disebabkan oleh ketiadaan model yang bersesuaian untuk mengaplikasi BIM dalam situasi latar belakang pembinaan Jordan pada masa kini.

ABSTRACT

Many countries consider the construction industry as one of the most challenging industries. The major problems facing construction companies and have ardently caused its low performance improvements over the years cannot be overemphasized. Among others, the causes include poor communications and exceptional fragmented environment relating to the construction sector. The Jordanian construction industry is a very crucial segment of Jordan's economy. In 2014, it contributed about 5.8% to the gross domestic product (GDP) of Jordan, which is more than the agricultural, electricity and water sectors. However, the construction industry in Jordan faces low productivity issue which is obviously due to repeated delays in the construction project besides cost overrun. On the other hand, many studies on the adoption of building information modelling (BIM) have been conducted in various countries including Norway, Finland, Sweden, Germany, Malaysia, Singapore, France, USA, Australia, and UK where BIM has proven the capabilities to develop information integration, business process flow, productivity, and reduce complexities, uncertainties, conflicts, and fragmentations, among others. BIM is the latest development which is a promising, an evolving procedural and technological shift within the AEC sector. This research is aimed to provide support development in the Jordanian construction industry practice by developing a BIM adoption framework. The contractors, owners and consultants can use this framework to assess and comprehend how ready they are for BIM adoption. To meet this aim, related literature was comprehensively elaborated in two contexts. The first context was the Jordan construction industry in order to explore the current criteria for construction practice and spot-related challenges. The second context was BIM technology, the concept, practice, development, adoption condition, and best practices to select the theoretical framework for BIM adoption from the best practices list. To conceptualize the selected theoretical adoption framework, the research followed a qualitative approach and 15 semi-structured interviews were conducted with the leading construction organizations in the Jordanian construction industry. Three levels of validity and reliability checks were performed; the first level was a focus group workshop where the researcher discussed the results with four construction experts who suggested some adjustments regarding the drivers' components in the theoretical framework, followed by the second level of validity where 228 questionnaires were answered by construction organizations. The results were analyzed using the structured equation modelling technique where one of the hypotheses were rejected and a second adjustment regarding the conceptual framework components took place. The last validity check was done by discussing the conceptual framework with the three major industry players in Jordan i.e. the ministry of public work and housing, the Jordanian construction contractors association and the Jordanian engineers association to generate the finalized adoption framework. Findings revealed that the adoption of BIM among construction organizations in Jordan is still at the pre-BIM stage where it faces barriers and confronts challenges such as, but not restricted to, the lack of BIM awareness, training centers, BIM specialists, government support, and financial resources, and resistance to change. This study proposed a practical conceptual BIM adoption framework validated by the construction industry key players where it is expected to support and accelerate the adoption operation amongst the Jordanian construction industry significantly. Moreover, the proposed adoption framework could be used as a benchmarking tool to measure the organizations' readiness to adopt BIM technology.

It had been observed from previous literatures (and later confirmed by the interviews and questionnaire results) that some of the problems faced by Jordanian construction industry are: poor design, poor scheduling and planning, change orders, lack of competitive technical staff and ineffective communications among others, leading to issues such as cost and time overruns.

Most of the participants approved that the use of ITC on their business increase their efficiency, saving time and decreasing cost. Nonetheless, the finding is different from that of the BIM. Numerous specialists from the construction body are aware of BIM but never applied it in practice. Also, some were familiar of the advantages of BIM, but majority stated they had no knowledge of BIM. In the same way, this study exposed that those experts who knew about BIM were in the age of 30-49. The people of older ages are uninterested in learning a new process. The fresh engineers have no idea about BIM.

The research proposed an expository revision that asset the best predictable adoption standards for BIM adoption. The adoption standards would help the firms to recognize the BIM field of capability and assess their present ability to adopt BIM.

Moreover, the study supposed to increase the present awareness on BIM by recording concerns associated with BIM adopting from the construction organizations viewpoint.

Furthermore, the results concluded in this study could assist the industry sector to realize the BIM adoption problem inside the situation of Jordan.

This research supposed to have a significant importance to the construction sector by reason of the absenteeism of a suitable model to adopt BIM in regard of the Jordanian construction background.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AEC	Architecture, Engineering and Construction
AIA	American Institute of Architects
ANZRS	The 'Australian and New Zealand Revit Standards’
AVE	Average Variance Extracted
B	Billion
BIM	Building Information Modelling
BIMADP	BIM Adoption
BIMAW	BIM Awareness
BIMCP	BIM Capability
BIMCS	Building Information Modelling Cloud Score
BIMUND	BIM Understanding
BPI	BIM Proficiency Index
BRR	Barriers
BRRCHL	Barriers and Challenges
CBJ	Central Bank of Jordan
CFA	Confirmatory Factor Analysis
C.R	Construct Reliability
CPI	Price Index
EFA	Exploratory Factor Analysis
GDP	Gross Domestic Product
HUDC	Housing and Urban Development Corporation
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
IDM	Information Delivery Manuals
IPD	Integrated Project Delivery
JD	Jordan Dinar
JCCA	Jordan Construction Contractors Association
JEA	Jordan Engineers Association
LOD	Level of details
MENA	Middle East and North Africa
MDV	Model View Definitions
MEP AUS	Mechanical, Electrical, and Plumbing Australia
MPWH	Ministry of Public Work and Housing
NATSPEC	National Specification
NBIMS	The National Building Information Model Standard
PLS	Partial Least Squares
PDM	Project Document Management
ROI	Return on Investment
SEM	Structural Equation Modelling
UK	United Kingdom
USA	United States of America
VDC	Virtual Design and Construction

LIST OF SYMBOLS

H	Hypothesis
P	Probability
R^2	Construct's percent variation
T	The size of the difference relative to the variation in the sample
V	validity

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