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BARRIERS AND CHALLENGES OF BUILDING INFORMATION MODELLING IMPLEMENTATION IN JORDANIAN CONSTRUCTION INDUSTRY

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KEYWORDS: Building Information Modelling, Jordanian Construction Sector, Implementation, Barriers and Challenges, Opportunities.

ABSTRACT
Construction companies are faced with the need to innovatively integrate the construction process and address project development challenges. One way of doing that is the integration of building information modelling (BIM) in the building design and development cycles. However, due to the lack of clear understanding and the absence of a holistic implementation guideline, many companies are unable to fully achieve BIM potentials or implement BIM in their project and building lifecycle. BIM implementation is increasingly challenging in the Jordanian construction industry. Research demonstrates that successful BIM implementation is possible through the identification of the barriers and challenges, which is a basic precondition for the transition of BIM in In the Jordanian construction industry. This study analyzes the barriers, challenges, and the maturity levels of BIM adoption in Jordan construction industry to develop a BIM implementation framework for better understanding of BIM. Thus, enables the industry towards more extensive BIM implementation. The researcher demonstrated this framework by analyzing survey responses to measure the challenges, barriers, and maturity of BIM's implementation and discuss the framework's utility for the Jordanian building industry.

INTRODUCTION
Construction companies are faced with the need to innovatively integrate the construction process and address project development challenges (Ansah & Sorooshian, 2017). One way of doing that is the integration of building information modelling (BIM) in the building design and development cycles. The use of BIM within the construction industry can be traced back to the past two decades (Khosrowshahi & Arayici, 2012). However, its use in the Middle East became more prominent in recent years and since that time, BIM is emerging as a new tool, both in construction management and practical sphere of building construction. There are, among others, some explanations for BIM adoption. One explanation has to do with the need to improve methods and tools to control fragmentation, risks and increase collaboration in construction projects. Likewise, the other explanation sees BIM as a framework designed to ensure better quality. Even so, it is indicated that BIM enhances sustainability, facilitates the integration of disjointed practices, reduces poor quality and acts as a catalyst for changing business process (Aranda-Mena, Crawford, Chevez, & Froese, 2009; Mihindu & Arayici, 2008). Generally, BIM is an interactive set of processes, policies, and technologies producing an approach to manage essential building designs and project data in a digital format all through the building's life-cycle. Thus, an emerging procedural and technological shift influencing all stakeholders within the architecture, engineering, and construction (AEC) industry.

Several studies have been carried out on BIM implementation in other countries including Finland, Norway, Sweden, Singapore, Germany, France, Australia, USA, Malaysia, and UK (Aranda-Mena et al., 2009; Khosrowshahi & Arayici, 2012; Mihindu & Arayici, 2008), and their implementation have shown potentials to increase productivity, information integration, business process flow, and reduce uncertainties, complexities, fragmentations, conflicts, among others (Khosrowshahi & Arayici, 2012). However, not much attention has been given to BIM implementation issues in Jordan. The implementation of BIM is a major change management task, encompassing diverse risk areas. Research demonstrates that successful BIM implementation is possible through the identification of the barriers and challenges, which is a basic precondition for the transition of BIM in Jordanian building sector. In other words, to ensure the achievement of BIM objectives, there is the need for a systematic evaluation of the barriers and challenges to ensure understanding for optimization of functions, business processes flow and effective communication among project teams. Moreover, in spite of the several attempts by companies to interpret and apply the BIM, many are still struggling with design quality issues, long lead times, and high design and execution costs, and these are mostly attributed due to the lack of clear understanding and the absence of a holistic implementation guideline. As a result, many companies are unable to fully achieve BIM potentials or implement BIM in the project design and development process.

The motivation behind this article is to analyze Jordan's construction industry to develop a predictive understanding of BIM implementation. Thus, the study analyzes the barriers, challenges, and the maturity levels of BIM Implementation in Jordanian construction industry to develop a BIM implementation framework for better understanding of BIM. This will enable the industry towards more extensive BIM implementation. The researcher demonstrated this framework by analyzing survey responses to measure the challenges, barriers, and maturity of BIM's implementation and discuss the framework's utility for the Jordanian building sector.

RELATED RESEARCH

The evolution and use of information technology (IT), data and computer science have transformed the work process of a number of industries (Chan, 2014). In fact, incorporating ICT tools into construction have been considered as being able to provide better solutions to design and the different construction processes and delivery issues. As argued by Lou & Kamar (2012), IT is an enabling component towards successful implementation of enterprise information tools. Likewise, the utilization of IT in construction enhances accuracy and information, support integration and facilitates clients' selection process, cost comparison, transportation and the entire logistics process (Ang & Kasim, 2013). It enables better conditions for efficient construction process where mistakes are detected early, thus avoiding any related issues in the assembly or construction stages (Hamid, Kamar, & Mustafa, 2009).

IT integrated construction is used for both a method of construction and computer-automated system which coordinates designing, production, construction, marketing and other support functions into intelligent automated construction processes (Ansah, Sorooshian, Mustafa, & Duvvuru, 2016; Laplante, 2005). One of such tools is BIM, a state of the art tool, with virtually a complete digital chain which is used from the early planning phase through to production. Functional areas include planning, design, analysis, inventory control, purchasing, distribution and cost accounting, among others. According to Waldner (1992), the functional areas are connected together as a system through a computer with factory floor capacities including material handling and management, direct control and monitoring of the entire operations.

- Building Information Modeling (BIM)

BIM, a three-dimensional (3D) parametric modeling software has the capacity to minimize several technical challenges in construction, especially prefabrication processes. For example, BIM can reduce the cost of rework and engineering cost due to defects in prestressed concrete companies. It essentially changes the traditional planning process and addresses the mass customization issues in manufacturing (Ang & Kasim, 2013). The benefits of BIM implementation include the consistency to automatically maintain diverse building parts and pre-programming design intent. It also improves engineering productivity, enables uninterrupted flow of information, reduces lead times, reduces design errors, and improves customer services by accommodating frequent changing demands by clients. It is more reliable in delivering projects within the shortest possible time and able to streamline the procurement of component parts or materials for production (Ansah et al., 2016). BIM is intended to deliver automated and interactive engineering and design, data storage, and facilitate design, assembly, and the entire building life cycle (Sacks, Eastman, Lee, & Orndorff, 2005). Similarly, through BIM, 3D models and 2D drawings can easily be extracted, thus reducing time, mistakes and errors caused by modifications (Andújar-Montoya, Gilart-Iglesias, Montoyo, & Marcos-Jorquera, 2015). BIM is very effective for maintenance and operation (Lin, Chen, Huang, & Hong, 2016), good for post-construction management as it enhances efficiency, security, and comfort of occupants (Zhang, Seet, & Lie, 2015), and efficient for design, construction, and operation of energy saving buildings (Jiang, Liu, Liu, Wu, & Anumba, 2016). In essence, it integrates engineering cycles from design through production to maintenance.

A study in Australia indicated that the effect of BIM has been remarkable across projects (Construction Training Fund, 2014). The Business Review Weekly on environment scan reported that "... The use of BIM in the potential to save construction firms between 3% and 5% in costs...BIM could have a huge effect not just in design and construction, but on the economy...could boost gross domestic product by 0.2 basis points above the "business as usual scenario" rising to 5 points by 2025" (Ansah et al., 2016; Construction Training Fund, 2014).

- BIM in the Middle East

The Middle East construction industry is gradually shifting from conventional systems to BIM (Gerges et al., 2017), thus an integrated computer-based construction. This tremendous transition has also been witnessed in Hong Kong, Australia, Singapore, USA, UK, Finland, Norway, Sweden, Germany, France, Malaysia, among others (Aranda-Mena et al., 2009; Khosrowshahi & Arayici, 2012; Mihindu & Arayici, 2008). BIM is a very powerful tool of design management which has been significant for the Architecture, Engineering and Construction industry. It has tremendous advantages for the entire project or building lifecycle, especially design but also facility and construction management. Even though its use is spreading widely and quickly, BIM is still relatively new in the Middle East (Gerges et al., 2017), specifically Jordan.

BIM implementation has been witnessed in Dubai, Kuwait, among others, however, the implementation rate is very low (Gerges et al., 2017). The report by BuildingSmart (2011) for the Middle East and Jordan indicated that the adoption of BIM is not mandatory in the region. The study demonstrated that only 25% of companies used BIM. Likewise, the report showed that the absence of BIM expertise was a concern since 64% of individuals who had BIM training were self-taught. Similarly, 62%of the respondents indicated that the primary reason why BIM has not been adopted is that clients do not request for the utilization of BIM. About 43% did not know how to utilize BIM, 41% were keen on using BIM yet do not have the technical know-how to start, and 19% indicated that BIM is too costly to use. Moreover, Awwad & Ammoury (2013) clarified that the Middle East has the most reduced BIM implementation rate, as the public sector is reluctant to implement its use. Also, professionals only see BIM as a tool for 3D modeling of the building. It is indicated that BIM is mainly used in the Middle East for design authoring, 3D coordination, and clash detection (Awwad & Ammoury, 2013). Mehran (2016) indicated that nonexistence of standards, high implementation costs and uncertainties surrounding profitability were the major challenges in the Middle East.

Although, these evaluations and reviews have contributed to the literature base in the Middle East in one way or the other, however, they mostly have been limited by their scope as they focused on UAE, or on only a few barriers and challenges of BIM, while neglecting other aspects. Also, some have been developed jointly or separately, from theory and practice. In confirmation of this literature gap, Mehran (2016) suggested for more research in identifying and analyzing BIM definitions, changes, awareness, challenges and how the challenges should be addressed.

Hence, the need for a quantitative analysis that is focused on Jordan.

RESEARCH METHODOLOGY

The main focus of this paper is to evaluate the current issues of BIM implementation of the Jordanian construction industry. Therefore, both quantitative and qualitative methods were applied in this research. Because it is a new phenomenon the contextual analyses and qualitative methods seem appropriate as they better explain why and how (Li, Wu, Zhou, & Liu, 2017). Figure 2 illustrates the research flow chart indicating the steps in the research methodology.

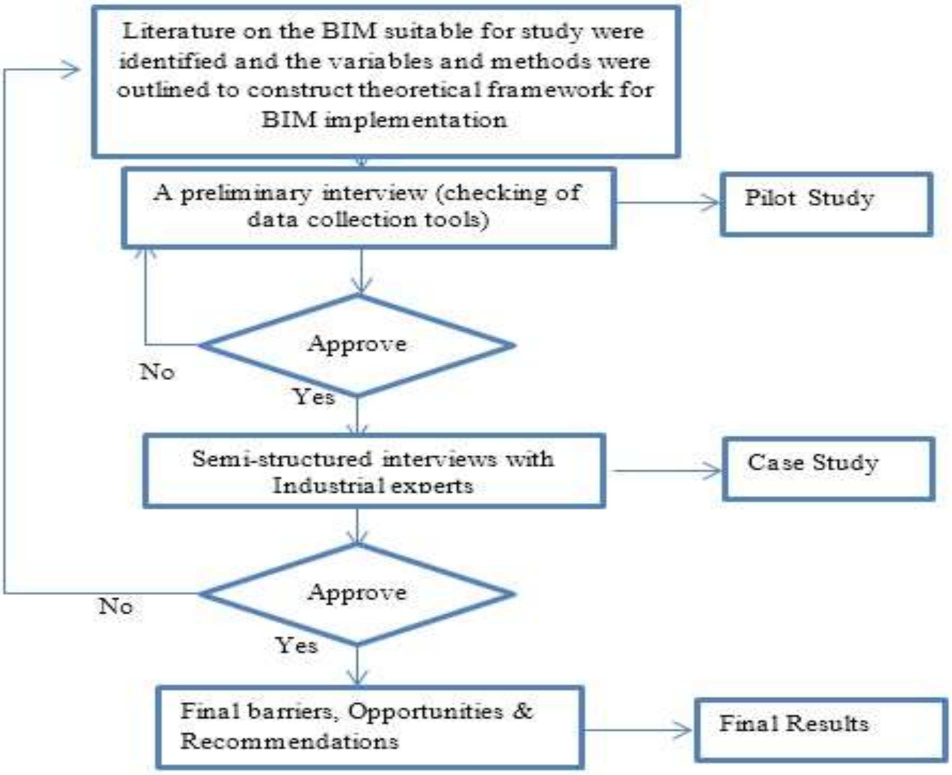

Fig. 1: Research Flow Chart

Clarifying the research problem ad scope is the key element to determining the most appropriate method for case study design, data collection, and analysis. Because the study is new, the qualitative methods and the contextual analyses seem suitable as they provide a better explanation of why and how (Li, Wu, Zhou, & Liu, 2017). Initially, the study identified barriers and challenges, and the drivers of BIM implementation based on a case in Finland, which is recognized as the most advanced in this scope to identify the best practices and a set of criteria for different levels of maturity (Khosrowshahi & Arayici, 2012). Next, the study identified 9 BIM barriers, and 9 challenges, and these were endorsed through a pilot study to check the data collection tools in terms of the suitability and the comprehensibility of the construct items. According to Yin (2009), a pilot case study helps to refine data content and the underlined procedure.

Then, a semi-structured interview was used for data collection. A list of 15 construction firms using BIM was invited and responded. These firms are classified as the highest grade of contractors based on their portfolios including experience, capital, the number of employees and activities in the industry.

- Case Study Research Process

In order to achieve the aim of this research, literature and document reviews, questionnaire and interview were employed as a data collection technique. There were five processes that were followed in this study. These included; study design (defining objectives and planning of case study), preparation for data collection (defining protocols and procedures for data collection), data collection (collecting evidence on the studied case), data analysis and reporting. Meanwhile, the questionnaire was designed through a brainstorming exploration process. The main questions were based on the drivers, challenges, and barriers of BIM. Figure 2 presents the questionnaire brainstorming.

A five point Likert Scale of I to IV in the questionnaire was adopted to assess the degree of agreement of each parameter where I represented ‘strongly disagree’, II ‘disagree’, III ‘uncertain’, IV ‘agree, and V ‘strongly agree’. The aim was to evaluate whether the perceived factors were more agreed upon and widely used. The interview mainly focused on the experts' opinion, experience and knowledge of the barriers, and challenges in their building projects. In the process, data on judgments made by the decision makers was weighted, and the basic descriptive statistics was computed. Consequently, by using this approach, the respondents' preferences were more precisely clarified. Emphatically, the purpose of the interview was to solicit realistic information and well as the views of the contractors on the implementation of BIM.

This study used an open-ended question to unearth the possible issues of BIM's implementation in the Jordanian construction industry. A semi-structured interview was used for the data collection and to gain much understanding through the opinions and views of the respondents. According to Saunders (2009), a semi-structured interview provides the opportunity to further evaluate the given responses. Respondents may express ideas and use words in diverse ways, thus the opportunity for better understanding which may add appreciation and depth to the data collected. This may lead to discussion into areas that were not previously considered yet are significant to the study. Nonetheless, he cautions that the researcher must be aware of the manner of interaction and how the respondents impact on the data obtained. The experts included project managers, site engineers, and stakeholders.

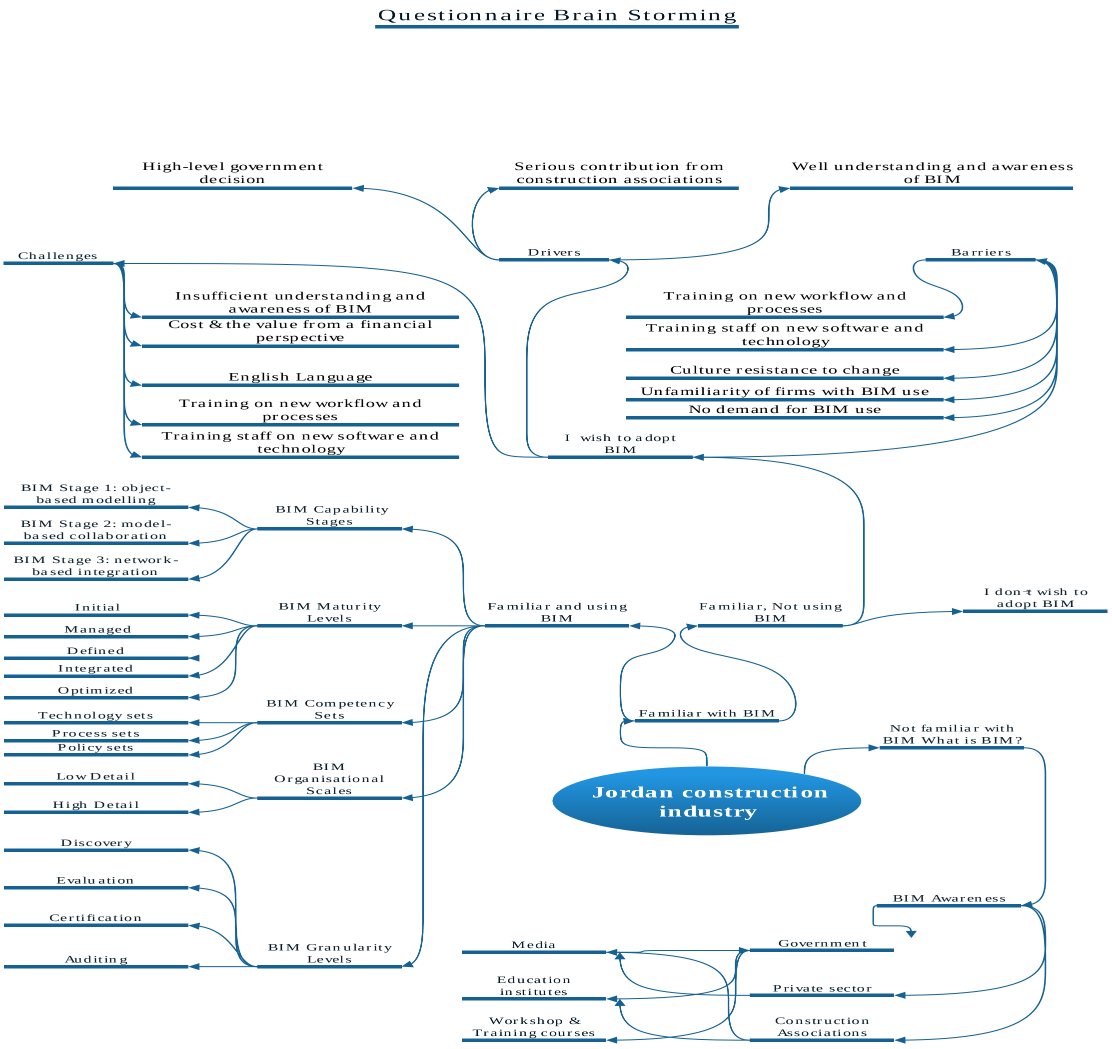

Fig. 2. Exploring Brainstorming

RESULTS AND DISCUSSION

The categories of the systematic analysis of the data are based on personal experiences and background of the respondents, their understanding and awareness of BIM, barriers, and challenges, services offered and the drivers and future potentials of BIM implementation. The descriptive statistics of the respondents' background is indicated below (refer to Appendix B).

Personal experience and background. The respondents reflected a wide variation in terms of years and experience. While 3 individuals have less than 10 years of experience, 12 individuals have over 10 years of experience in the industry. This implies that the general overview of the results was dominated by individuals who have significant experience and comprehension knowledge about the development of the construction industry in the most recent decade. Thus, the survey results were able to reflect the use and attitude of BIM across the Jordan construction industry.

BIM understanding. As shown in Figure 3, there were variations in the understanding of BIM from the 5 different BIM definitions by Khosrowshahi & Arayici (2012). 13% characterized BIM as 3D modelling while 33% defined BIM as a 3D intelligent. Likewise, 27% believed that BIM is a computable 3D. 13% saw BIM to be Multidimensional data and finally, 13% as a 5D modelling. With such a varying understanding, these definitions were evaluated to reflect the maturity levels of understanding and awareness.

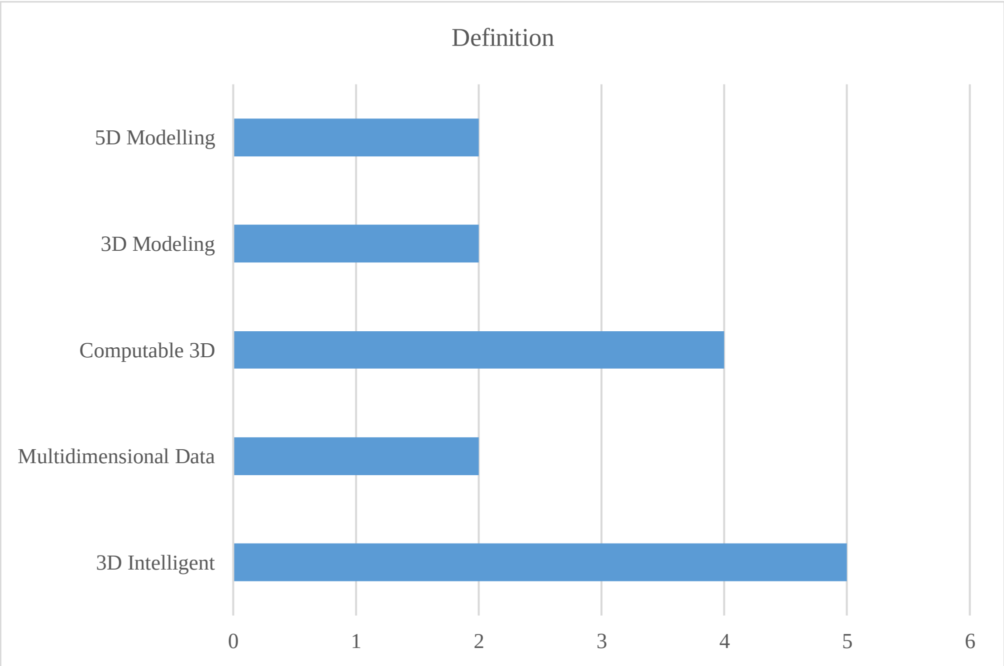

Fig. 3. Levels of Maturity Stages based on Definitions

Barriers and Challenges to BIM. The primary reasons behind the barriers and challenges of BIM implementation in Jordan are presented in Tables 1 and 2. It is observed that more that 70% agreed with the barriers whereas more than 80% agreed with the challenges for BIM implementation. Also, the challenges were found to be in agreement with the identified barriers. Furthermore, the results indicated that practitioners need clear guidance, training, and technical support for effective BIM implementation in Jordan as they do not have enough experience knowledge about BIM at Stage 2 and Stage 3 maturity levels. In terms of the vision and future estimates for BIM implementation, most of the respondents believed that government assistance would enable effective implementation of BIM (refer to Appendix A).

Table 1 Barriers to BIM

No	Barriers to BIM	Likert Scale				
		I	II	III	IV	V
1	Firms are not familiar enough with BIM use	-	-		3	12
2	Reluctance to initiate new workflows or train staff	-	1	4	6	4
3	Benefits from BIM implementation do not outweigh the costs to implement it	-	4	2	4	5
4	Benefits are not tangible enough to warrant its use	-	-	1	6	8
5	BIM does not offer enough of financial gain to warrant its use	-	5	1	5	4
6	Lacks the capital to invest in having started with hardware and software	-	-		6	9
7	BIM is too risky from a liability standpoint to warrant its use	-	1	4	5	5
8	Resistance to culture change	1	4	1	5	4
9	No demand for BIM use	2	4	1	5	3
Total		3	19	14	45	54
Percentage (%)		6%	14%	10%	30%	40%

Table 2 Challenges to BIM

No	Challenges to BIM	Likert Scale				
		I	II	III	IV	V
1	Training staff on new process and workflow	-	-	2	4	9
2	Training staff on new software and technology	-	-	-	7	8
3	Effectively implementing the new process and workflow	-	-	-	7	8
4	Establishing the new process, workflow and client expectations	-	-	-	5	10
5	Understanding BIM enough to implement it	-	-	1	9	5
6	Realizing the value from financial perspective	-	-	2	8	5
7	Understanding and mitigating liability	-	1	4	5	5
8	Purchasing software and technology	-	-	-	3	12
9	Liability for common data for subcontractors	-	3	4	5	3
Total		0	4	13	53	65
Percentage (%)		0%	3%	10%	39%	48%

Figure 4 presents the distribution of the answers to the question of what services the respondents think BIM is capable to offer to clients.

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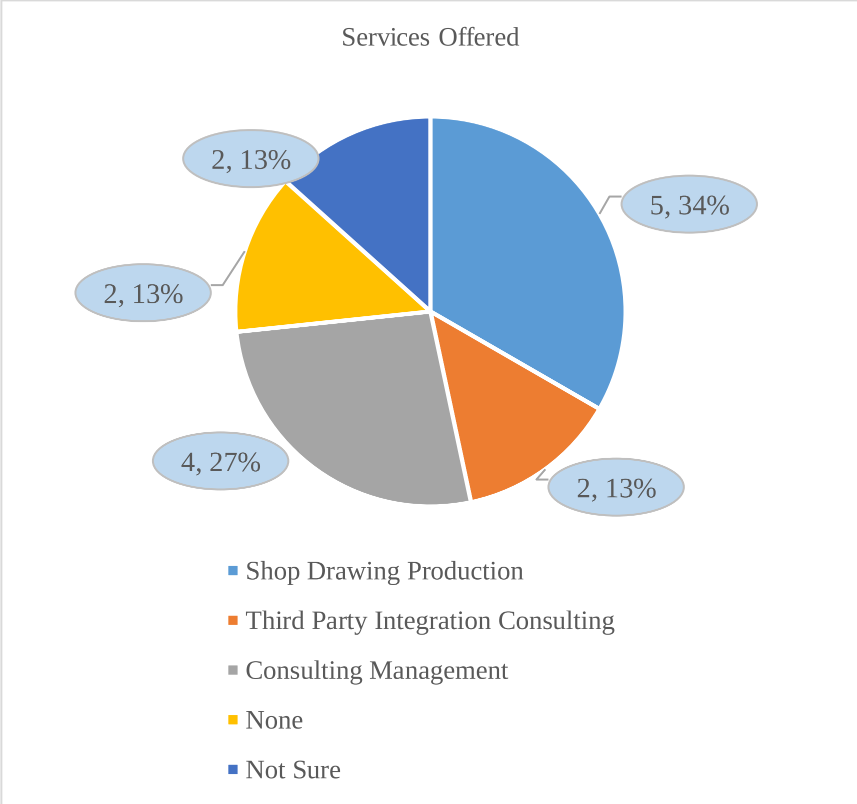

Fig. 4. Services Offered by BIM

From the Figure above, it is observed the about 13% selected Third Party Integration Consulting, None and Not Sure (for each service) while 27% and 34% were selected for Consulting Management and Shop Drawing Production respectively. Therefore, nearly half of the respondents have a realized vision limited to BIM maturity stages as they only realize BIM in practice from the BIM tools. Similarly, the respondents indicated the following added-value BIM services to be offered:

- Information management for the building lifecycle
- Increased efficiency leading to improved design
- Visualization to manage client expectation and enables awareness for training
- Helping clients develop BIM capability themselves
- Guidelines, implementation support, and monitoring; visualization, 3D walkthroughs, quick analysis of alternatives
- Quick revisions to schemes
- High-quality documentation
- Material supplier integration and better modelling

In terms of BIM awareness, the study found that 80% were aware of BIM. This is illustrated in Figure 5 indicating the overall conceptual framework for BIM implementation in Jordanian construction industry. It is expected that this framework would serve as a guideline to enable the Jordanian construction industry towards more extensive BIM implementation.

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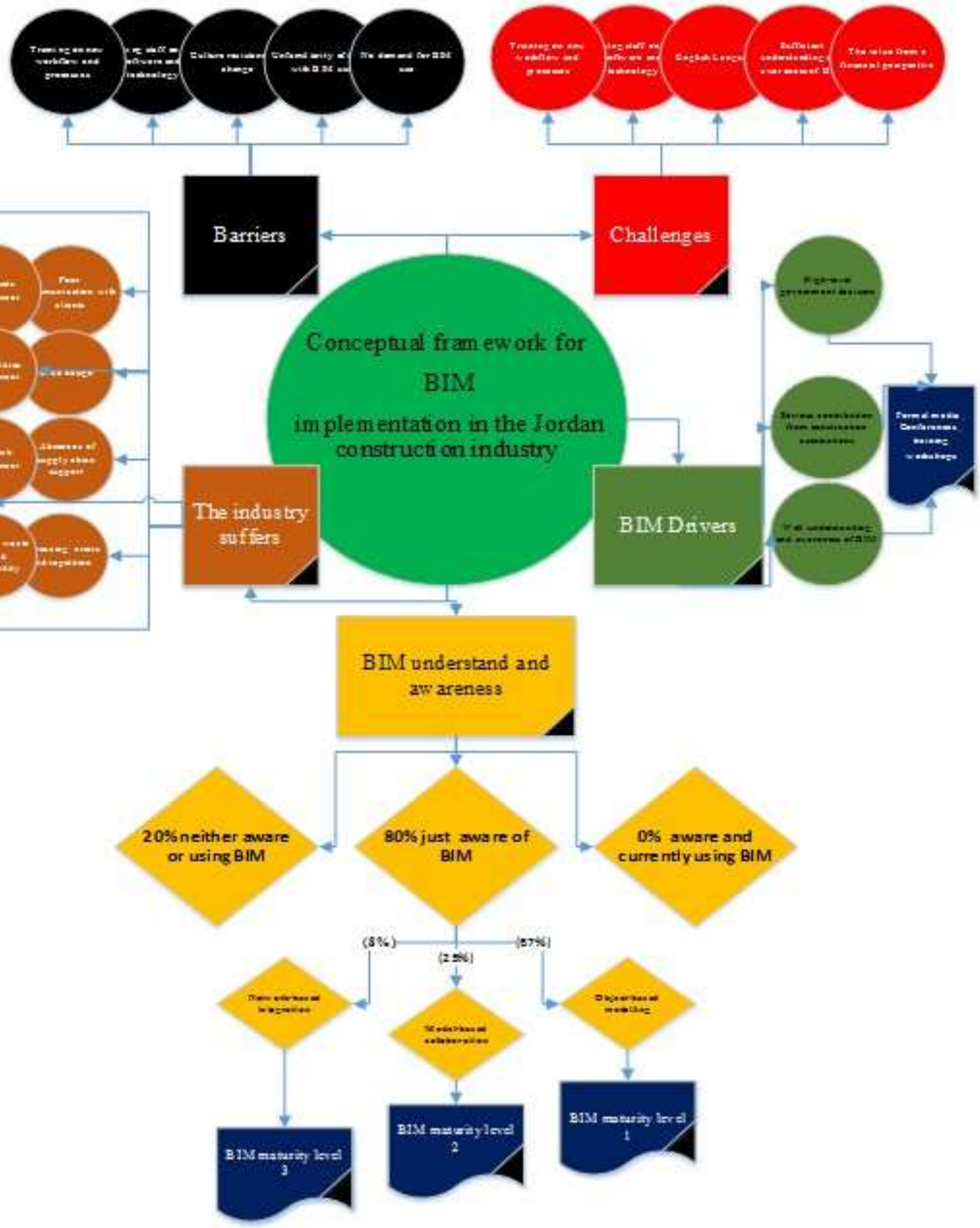

Fig. 5. Overall Conceptual Model for BIM Implementation

CONCLUSION AND RECOMMENDATIONS

BIM implementation increasingly becoming a must for the architecture, engineering and construction industry to innovatively integrate the construction process and address project development challenges to stay competitive. Through the use of BIM maturity gauge, the study demonstrated that about 80% have fair awareness about BIM, which constitutes major challenges for adoption. The study highlighted relevant issues including lack of training staff on new process and workflow, lack of training staff on new software and technology, absence of effective implementation of the new process and workflow, the lack of establishing the new process, workflow and client expectations, lack of understanding BIM enough to implement it (challenges), the lack of familiarity with BIM use, reluctance to initiate new workflows or train staff, lack of the capital to invest, the risky nature of BIM tools from a liability standpoint, resistance to culture change (barriers), among others. Meanwhile, the results indicated that there is the need for training, client and government support to effectively mitigate the barriers and challenges to implementation. Moreover, an implementation guideline has been highlighted to help address BIM implementation issues, thus, enabling the achievement of BIM potentials or implementation in the project design and development processes.

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Appendix A Vision and future estimates for BIM implementation

No	Barriers to BIM	Likert Scale				
		I	II	III	IV	V
1	Do you agree that BIM will result in improving the construction practices?	-	-	-	2	13
2	High percentage of firms/organizations are using BIM currently for their projects?	12	1	2	-	-
3	Do you think it will take short time (5 years) before 50% of the Jordanian AEC industry uses BIM on a regular basis?	1	4	4	4	2
4	Do you expect that governmental assistance will be received by your firm soon (5 years) to take up BIM?	2	2	2	6	3
5	Do you think its governmental action that should be taken to go ahead with BIM uptake?	-	1	1	8	5
Total		15	8	9	20	23
Percentage (%)		65%	6%	7%	15%	17%

Appendix B Respondents Background

Age	Job Description	Years of Experience	Working For
28	Site engineer	4	Consultant
30	Quantity surveyor	6	Consultant
35	Quantity surveyor	12	Contractor
35	Site engineer	10	Owner
39	Top management	15	Consultant
40	Site engineer	12	Contractor
40	Survey Engineer	15	Owner
43	Site engineer	18	Consultant
45	Top management	15	Contractor
46	Executive manager	16	Contractor
48	Planning engineer	22	Contractor
51	Quality control engineer	20	Owner

53	Project manager	20	Contractor
56	Project manager	30	Owner
58	Project manager	30	Consultant