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Journal of Construction in Developing Countries

Manuscript Title	A BIM Plan of Work for Managing Construction Projects in Egypt
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Submitted Date	8-Feb-2018 (1st Submission)
Accepted Date	3-Jul-2018

A BIM Plan of Work for Managing Construction Projects in Egypt

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Abstract
The RIBA Plan of Work together with BIM guidance documents, developed in the UK, are commonly used in Egypt and the Middle East. However, efforts from academics publishing articles about the experiences of the adoption of such BIM standards in Egypt have been very limited. This research investigates the use of a BIM-RIBA Plan of Work in the construction industry in Egypt. The research aim was achieved through literature review and collecting qualitative data from industry practitioners. Focus group interviews was used to collect qualitative data, then analysed through consecutive stages of transcription, coding and structuring. The main finding of this study is that integrating the RIBA Plan of Work in Egypt would be beneficial only if the established construction activities have been further detailed and linked to BIM concepts. A BIM-RIBA Plan of Work has been developed through the identification of main BIM objectives and activities in each stage in the project lifecycle.

Key words: BIM, Construction Projects, Egypt, Integrated Project Delivery, RIBA Plan of Work

1. Introduction

For some time now, housing and infrastructure projects have become the main priority for the Egyptian government (Bank Audi 2016). The construction sector accounted for 4.8% of Egypt's Gross Domestic Product (GDP) in 2015 (Bank Audi 2016). The Egyptian government is currently undertaking several large projects in power, residential, retail and infrastructure fields. A Power Supply Programme 2010-2020 has been developed with the aim of adding 30,000 Mega Watts to the country's current electrical capacity. The programme includes several renewable energy generation projects in addition to a nuclear power plant, with an annual investment in excess of £3 billion (Gov.uk 2015). In the infrastructure field; ports, factories and logistics centres are being developed in the Suez Canal Zone Project with an estimated worth of about £20 billion over 15 years (Gov.uk 2015). The "New Cairo Capital" city is being developed, and parts of the city have already been constructed at the west side of Cairo, worth an investment of £30 billion (Gov.uk 2015). Despite the growing demands of building in Egypt, the construction sector has been noted to be inefficient and underperforming. Some of the reasons of the poor performance of the construction sector are the lack of advanced procurement management techniques, absence of marketing strategy, lack of industry standards and statistics (Sakr, Sherif et al. 2010). The construction industry in Egypt is also

characterised by poor management and poor working conditions (El-Gohary and Aziz 2014). In addition, the industry is faced with many political and economic risks, following the political disturbance and social instability including governmental changes, currency fluctuations, worker's strikes and fire risks (Khodeir and Mohamed 2015). From an environmental perspective the performance of the industry is also wanting, with the sector responsible for 28% of the total CO_2 emissions in Egypt (Sameh 2014). The rapid rate of urbanisation and increasing pressure on what are often limited resources urges for the need to manage resources in a more sustainable manner (Reffat 2004).
The solutions to the aforementioned challenges lies in the adoption Building Information Modelling (BIM), an emerging technology in the Architectural, Engineering and Construction industry (AEC) (Arayici, Coates et al. 2011). The global BIM market is expected to grow form $1.8 billion in 2012 to $6.5 billion in 2020 (Machinchick and Bloom 2012). However, similar to the majority of developing countries, the construction industry in Egypt is lagging in the adoption of new technologies aiming to improve quality of construction. This is further exacerbated by the fact that the Egyptian government does not promote the utilisation of BIM in public works, and does not provide strategies, standards or vision for BIM adoption in construction projects (Elyamany 2016).

In the light of the large number and scale of the infrastructural, residential and commercial projects in Egypt in the upcoming 15 years, there is a need to improve the performance of the construction sector. The hazardous nature of the construction industry, in addition to the high environmental impact, and the rising cost of transportation and construction are the main drivers to adopt safe and sustainable construction methods and reduce the overall project lifecycle cost (Abdul-Rashid, Bassioni et al. 2007, Ibrahim, Eldaly et al. 2014, Sameh 2014). A proper adoption of BIM should enable the construction sector in Egypt to increase productivity, reduce lifecycle cost and delivery time, provide higher levels of certainty, and minimise the waste and environmental impact of the construction process (Arayici, Coates et al. 2011, Azhar 2011, Race 2012, Abanda, Vidalakis et al. 2015). Thus, some construction firms in Egypt and the Gulf Cooperation Council (GCC) countries are now adopting BIM in their projects partly due to market demand pressure (Gerges, Austin et al. 2017) regardless of the challenges discussed earlier. However, BIM-enabled projects in the Middle Eastern countries usually follow the philosophies and techniques which are tailored to the standards and construction practices in the UK. Some examples of UK standards being adopted in the Middle East including Egypt are PAS1192, CIC BIM Protocol, RIBA Plan of Work, etc. Given the social and economic differences between the UK and Middle Eastern countries, the difference in the practices and methodologies used in the construction sector are not necessarily the same to say the least. Bui, Merschbrock et al. (2016) argued that construction firms in developing countries suffer from several limitations related to the difference in the socio-economic and technological environment between developing and developed countries. Abdel-Razek (1998) indicated that the efforts made to improve construction performance in developing countries should relate to their economic, political, social and technological environment. Thus, the endeavours to standardise the practices and methodologies should be tailored to the Egypt's social and economic aspects. This requires learning from current adoption of UK BIM standards and processes by construction firms in Egypt. The key research questions are: What are the benefits and

challenges of adopting the RIBA Plan of Work into practices in Egypt? How can BIM and RIBA plan of Work be integrated to facilitate BIM compliant project delivery? How can BIM processes and RIBA Plan of Work be integrated to meet the needs of practices in Egypt? What can be done to foster the effective and efficient adaption and adoption of an integrated BIM-RIBA Plan of Work in the Egyptian construction industry?
The aim of this study is to investigate the integration of BIM-RIBA Plan of Work for the delivery of construction projects in Egypt. The specific objectives are to:

A. investigate the benefits and challenges of integrating RIBA Plan of Work into construction in Egypt;

B. how to integrate BIM activities into the RIBA Plan of Work;

C. compare the integrated BIM-RIBA Plan of Work over traditional project lifecycle stages in Egypt;

D. propose future research opportunities.

2. Literature Review

2.1. Building Information Modelling adoption in Egypt

BIM is a revolutionary development in the AEC industry that is believed to be able make a comprehensive improvement in the industry's current practices and methodologies by changing the way of collaboration and information distribution throughout project lifecycle (Succar 2009, Arayici, Egbu et al. 2012, Abanda, Vidalakis et al. 2015, Hardin and Mccool 2015). At its heart, BIM is the effective management of a huge amount of information that is generated throughout the course of a construction project and added to the operational life of the asset produced (Sands 2015). Many benefits have been attributed to BIM implementation in building design, construction and operation. Benefits include greater collaboration and enhanced communication (Race 2012, Abanda, Vidalakis et al. 2015), reduced lifecycle costs and project delivery time (Arayici, Coates et al. 2011, Azhar 2011), more accurate cost estimates and automatic scheduling take-off (Race 2012), greater visual clarity (Cousins 2016) and increased profitability and Return on Investment (Reddy 2012).
BIM has been adopted in many countries since the early 2000s (Jung and Lee 2015). The Middle East and Africa are considered to be in the "beginner phase" in BIM adoption status, despite the rising rate of BIM adopted projects (Jung and Lee 2015, Mehran 2016, Gerges, Austin et al. 2017). The introduction of mandatory policies by governments or public organisations to promote the uptake of BIM is a key factor that have influenced the adoption of BIM in countries like the UK (Abanda and Tah 2014, Cheng, Lu et al. 2015). However, the construction sector in Egypt does not have a clear understanding on the application of BIM, urging for the need to provide more knowledge and information to the sector (Elyamany 2016). In addition, the Egyptian government does not promote the use of BIM and has no published guiding documents or standards related to the BIM field (Elyamany 2016). Gerges, Austin et al. (2017) conducted a survey about BIM status in the Middle East, showing that only 20% of AEC

companies are using BIM or are involved in the BIM implementation process. However, the same survey indicates more awareness about BIM between individuals, showing that 60% of respondents reported to have between 3 to 9 years of experience, and have been involved in at least 2 BIM projects. It is worth mentioning that the findings from BIM research in the GCC countries can be applied to Egypt and vice versa, due to the similarity in construction trends and practices (Salama, Abd El Aziz et al. 2006).

2.2. BIM Process Development

A standard representation of project information throughout its lifecycle is imperative when the communication between various disciplines and specialists takes place, over long periods (Howard and Björk 2008). In addition, adopting a standard process map of project lifecycle should facilitate the automation of engineering modelling processes and quantify information waste (Verhagen, Vrught et al. 2015). Moreover, standardising project lifecycle stages should enable the automatic generation of work packages, and subsequently, automate project progress measurement (Ibrahim, Lukins et al. 2009). However, it has been argued that the absence of published BIM standards and guidelines, especially related to BIM process development in the Middle East is inhibiting the gaining of BIM benefits throughout project lifecycle (Mehran 2016).

There have been several endeavours to publish a standardised BIM process throughout project lifecycle; however, each publication placed more emphases on various aspect not necessarily related to integrated BIM-RIBA plan of work. While the focus of the RIBA Plan of Work was on detailing project lifecycle stages and providing a list of activities to be carried out at each stage, the CIC BIM Protocol put more focus on the content of data drops, the level of model detail in every stage, and project team roles and job descriptions (CIC 2013). On the other hand, the British Standards Institute (BSI) in collaboration with other research institutes introduced PAS1192-2 and PAS1192-3, describing the management of project information throughout its lifecycle. The PAS1192-2 and PAS1192-3 introduced the utilisation of standard main documents for the information management process, such as the Employer Information Requirement (EIR), Organisation Information Requirements (OIR) and BIM Execution Plan (BEP) (BSI 2013, BSI 2014, BSI 2014). In addition, the Digital Plan of Works (DPoW) was developed by the BIM Task Group, and it is oriented around the management of information created, developed and used within BIM models, mainly related to their structure and Level of Development (LOD), throughout project lifecycle (BIM Task Group 2013).

2.3. The RIBA Plan of Work

Many standards relevant construction project life cycles exist but it has been argued that incorporating BIM paradigm into them is a huge challenge (Ahmad, Demian et al. 2012). The Royal Institute of Architects introduced the RIBA Plan of Work 2007 (RIBA PoW), providing a shared framework for managing building project information during its lifecycles. The Plan of Work was in a form of a matrix, indicating a set of key tasks to be undertaken at each stage. The project lifecycle stages were defined to be: Preparation, Design, Pre-Construction, Construction and Use. Another version was published in 2013, providing more detailed project lifecycle stages and more flexibility to include multiple procurement routes instead of the selected traditional procurement route in the 2007 version (RIBA 2013). However, the 2013 version has been criticised for being too architect-focused and for condensing construction into a single stage (Designing Buildings Ltd. 2017). Both 2007 and 2013 versions did not relate to BIM in any of the mentioned roles, tasks or deliverables.

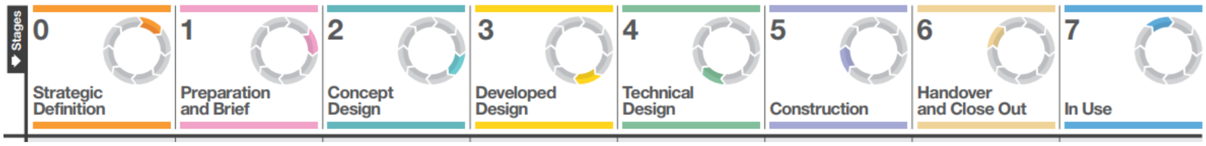

Figure 1: Project lifecycle stages in RIBA Plan of Work 2013 (RIBA 2013)

BIM Overlay to the RIBA PoW was introduced in 2012 based on the 2007 version of the RIBA PoW (Sinclair 2012). The BIM Overlay introduced core BIM activities to be carried out in each project lifecycle stage. The BIM activities focused on sustainability aspects. Indeed, the Overlay is about how BIM can be used in delivering sustainability aspects of a construction projects. At the end of each stage, information exchange should take place between stakeholders in what is called a Data Drop. The BIM Overlay followed the Green Overlay (Gething 2011), which was focused on sustainability key tasks and objectives throughout project lifecycle. However, the objectives identified in the BIM Overlay are too general, and does not indicate standard content of Data Drops, and does not identify submission protocols or quality gates between stages, in addition to the focus on sustainability activities. Moreover, the table structure of the RIBA PoW does not enable the modelling of the information flow between project main participants throughout project lifecycle.

2.4. Construction Project Lifecycle in Egypt

Perhaps, partly due to the fact that the Egyptian government does not promote the use of BIM in the construction sector (Elyamany 2016), there is a lack of publications and guidance on the subject of developing a standard BIM process. Hence, a document has been obtained from a real BIM implementation project in Dar Al-Mimar Group (DMG) Company, illustrating information flow between project stakeholders throughout traditional project lifecycle stages. DMG is a group of companies, specialised in the development, design, construction and operation of luxury real estate apartments, and is located in Cairo, Egypt (DMG 2011). The document obtained, was an assessment of the 'as-is' condition of the group, as a first step in their BIM implementation. The BIM implementation was managed by Virtual Projects, a BIM consultant located in Cairo, Egypt (Virtual Projects 2015). *Figure 2* shows a simplified version of the project lifecycle obtained from DMG.

While the process map structure is more advantageous over the table structure of the RIBA PoW in showing the interdependencies between project stakeholders, there is no description of the activities to be carried out in each stage. In addition, the project lifecycle in Egypt does not promote Integrated Project Delivery, as there is no indication of early involvement of the contractor or the facility manager before the Preconstruction stage. Worth to mention that the project lifecycle process map shown in *Figure 2* is not an agreed country standard in Egypt, but rather was developed by the participation of AEC companies under DMG.

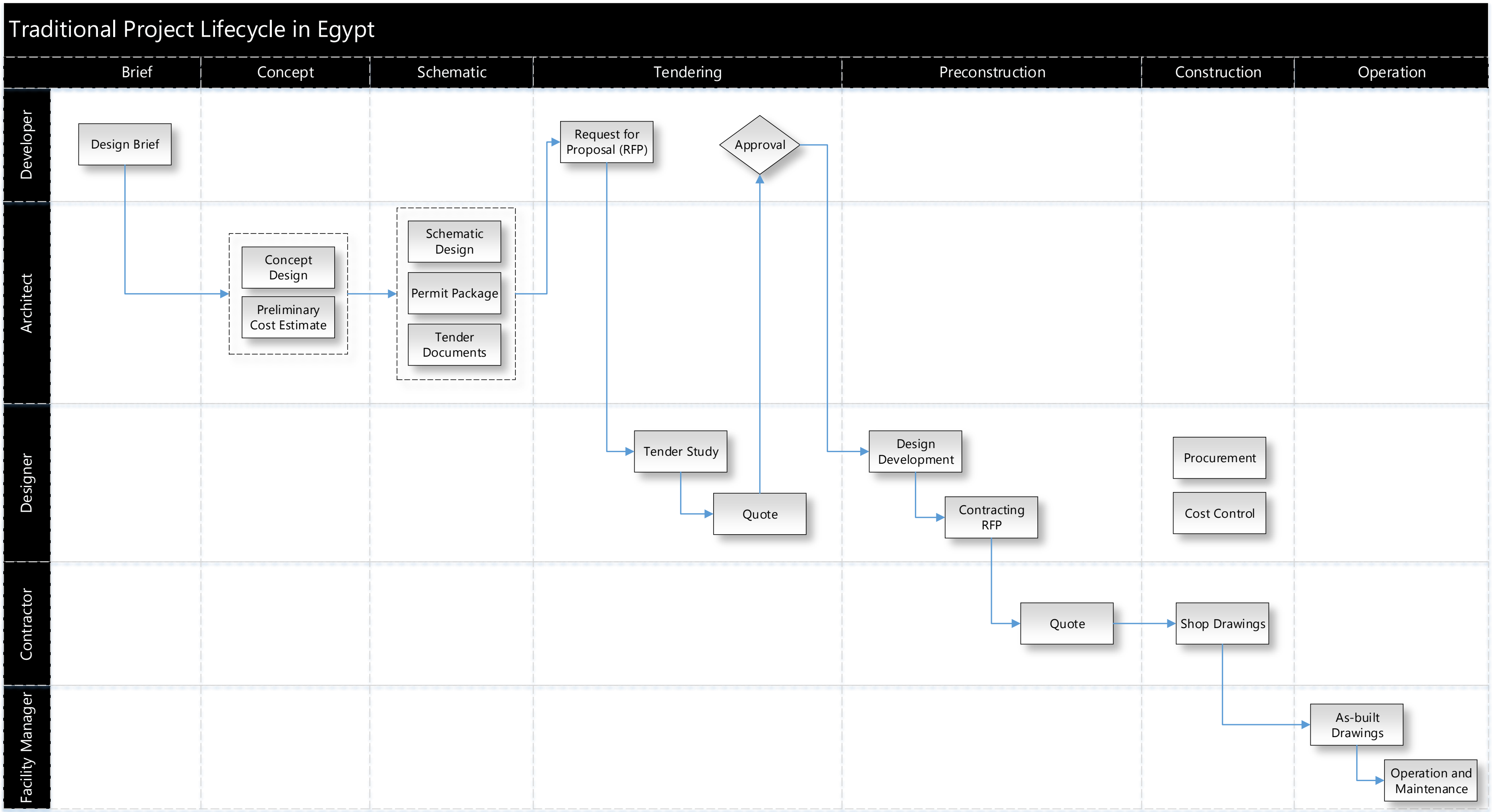

Figure 2: Traditional Project Lifecycle in Egypt

In surmise, a number of issues can be deduced from the review in the preceding sections. Firstly, while standard project life cycle is well established in the developed countries, e.g. RIBA plan of work, it is not common in Egypt. The sketchy lifecycle framework proposed by DMG in Figure 2 is not standardised. Secondly, efforts are already being made in the UK to incorporate BIM into the standard project life cycle (e.g. Sinclair (2012)), an aspect yet take off in Egypt. Thirdly, in an effort to improve efficiency, Middle East countries including Egypt are increasingly adopting UK BIM and project life cycle standards. However, their experiences have not been captured in peer-reviewed literature. Thus, the need to investigate the issues related to the adoption of UK BIM and project life cycles by Egyptian construction companies. To achieve this aim, an appropriate methodology will be pursued.

3. Research Methodology

3.1. Data Collection Methods

In this section the research methods used and their justification will be discussed. *Table 1* shows the selected research methods, mapped against corresponding research objectives, and the expected outcomes.

Table 1: Research methods and the expected outcome for each research objective

Objective	Methods	Outcomes
A	Focus Group	A list of benefits and challenges of integrating RIBA PoW in Egypt
B	Literature Review + Focus Group	A list of BIM objectives, activities and deliverables at each stage of the project lifecycle in the RIBA PoW
C	Literature Review + Focus Group	Integrated BIM-RIBA PoW based on Egyptian construction industry practices
D	Personal Discussion + Focus Group	A list of points that require further research and investigation

3.2. Data Analysis Methods

Grounded theory has been selected as the data analysis approach. Analysing qualitative data comprises five main stages: Preparation, Summarising (Coding), Categorisation, Structuring and Interpretation (Saunders, Lewis et al. 2009, Creswell 2014). *Table 2* shows a description of qualitative data analysis stages.

Table 2: Description of the stages of qualitative data analysis process used in this research

Stage	Description
Preparation	A transcript is produced from recorded audio material, of each focus group.
Coding	Transcript data are organised, by labelling specific segments with descriptive meanings, in a process known by “The coding process”. The labelled segments mark interesting features of the data, related to the research objective. Codes were generated based on emerging information collected from participants, during the analysis of transcripts. This method was selected because it is more suitable for social science research than using a codebook with predetermined codes (Creswell 2014).
Categorisation	Common themes/categories are generated through recognising the relationships between summarised data. These categories represent the major findings of the research (Creswell 2014).
Structuring	A structure of common themes and sub-themes is made, supported by quotes from the transcript.
Interpretation	Interpretations are made of research findings, i.e. lessons learnt from the research. The output of this stage is mainly based on the researcher’s personal interpretation of the research findings.

3.3. Sampling Technique

Achieving research objectives requires certain characteristics of the research sample, e.g. background, BIM experience, specialisation…etc. The criteria for selecting participants for the focus groups were the availability of BIM experience, in addition to the involvement in different project lifecycle stages. Fifteen participants were selected with disparate background (Architecture, Building Services, Structural…etc.) and backgrounds (Design, Construction, Project Management…etc.). However, it was not possible finding participants with facilities management background who have been involved in construction projects using BIM.

3.4. Justification of Selected Research Methods

The core of this study is about the issues associated with the adoption of UK RIBA Plan of Work and BIM standards in Egypt. Obtaining any data or information related to such issues can be informed by the experiences and perspectives of industry practitioners. Hence, the qualitative research method is very suitable to this type of research (Onwuegbuzie 2003, Kothari 2004, Saunders, Lewis et al. 2009, Creswell 2014). The adopted data collection technique is the focus group technique, as it will enable the investigator to interview a larger number of respondents, in addition to exploring a breadth of points of view from participants. In addition, the focus group will stimulate the debates and conflicts between different specialities throughout project lifecycle, as the opinion of one participant will be validated by other participants (Krueger 1997, Freitas, Oliveira et al. 1998, Naoum 2007, Onwuegbuzie, Dickinson et al. 2009).

The location for conducting focus groups, has been selected to be easy to find by participants, free from noise distraction, and equipped with the required furniture and audio facilities (Freitas, Oliveira et al. 1998). Audio-recording has been selected to record the interview data, as it enables the interviewer to concentrate on questioning and listening, in addition to enabling the re-listening of the interview for more in-depth analysis (Saunders, Lewis et al. 2009). Two main equipment were used during the focus group interviews. Firstly, projector / 40" TV + PC was used to present the RIBA Plan of Work and the traditional project lifecycle stage in Egypt. Secondly, an audio-recording software was used to audio-record the focus group discussion in an acceptable quality.

4. Data Collection and Analysis

4.1. Overview of Participants

The BIM experience of participants ranges from 3 years to 7 years, while their field experience ranges from 3 years to 10 years. All participants have been involved in at least two building projects using BIM. The background of all participants is mainly related to the design and construction stages. The inclusion of different backgrounds and experiences should stimulate a comprehensive discussion about main activities in the plan of work. In addition, the variety in participants' backgrounds should minimise the bias of a certain opinion towards a specific trade or stakeholder. Figure 3 shows a summary of participants' experiences and backgrounds.

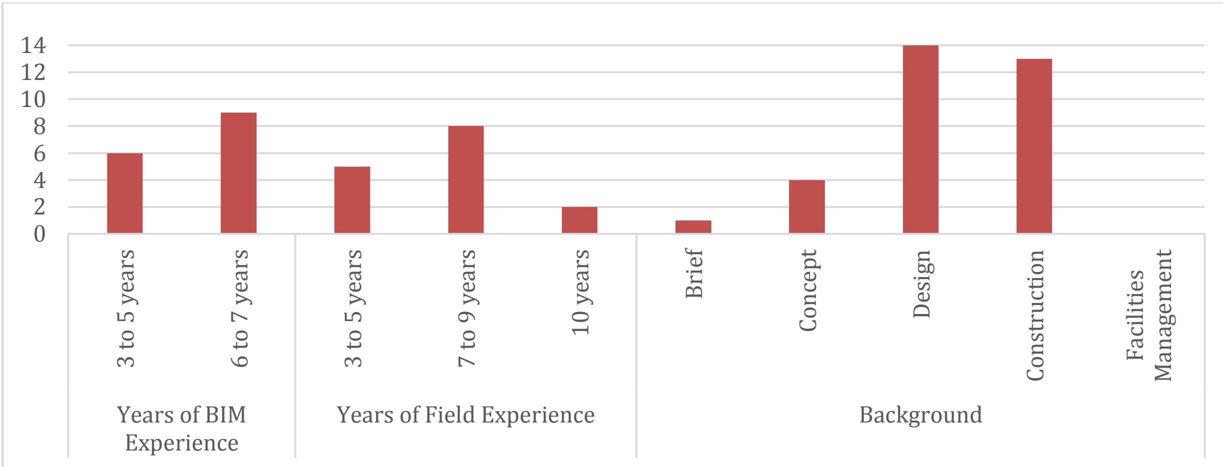

Figure 3: A summary of the experience and background of focus group participants

Table 3 shows a summary of backgrounds of participants in Focus Group I. The BIM experience of Focus Group I participants ranges from 5 to 7 years, while the field experience ranges from 7 to 10 years. The experience of participants is mainly related to the design and constructions stages.

Table 3: Focus Group I participants overview

Focus Group I			
Name	**Title**	**Background**	**Experience**
Participant A (Par. A)	BIM Manager	Design, Construction	6 years BIM Experience 10 years Field Experience
Participant B (Par. B)	Arch./Struc. BIM Coordinator	Design, Construction	5 years BIM Experience 7 years Field Experience
Participant C (Par. C)	Mechanical BIM Team Leader	Design, Construction	6 years BIM Experience 7 years Field Experience
Participant D (Par. D)	Electrical BIM Team Leader	Design, Construction	7 years BIM Experience 9 years Field Experience
Participant E (Par. E)	MEP BIM Coordinator	Design, Construction	6 years BIM Experience 7 years Field Experience

Table 4 shows a summary of backgrounds of participants in Focus Group II. The BIM experience ranges from 3 to 5 years, while the field experience ranges from 2 to 5 years. All participants have been involved in the design and construction stages.

Table 4: Focus Group II Participants Overview

Focus Group II			
Name	**Discipline**	**Background**	**Experience**
Participant A (Par A)	Arch. BIM Team Leader	Brief, Concept, Design, Construction	3 years BIM Experience 12 years Field Experience
Participant B (Par B)	BIM Consultant	Design, Construction	7 years BIM Experience 7 years Field Experience
Participant C (Par C)	Arch./Struc. BIM Coordinator	Concept, Design, Construction	6 years BIM Experience 7 years Field Experience
Participant D (Par D)	Arch. Senior BIM Engineer	Design, Construction	6 years BIM Experience 9 years Field Experience
Participant E (Par E)	MEP BIM Coordinator	Design, Construction	4 years BIM Experience 7 years Field Experience

Table 5 shows a summary of backgrounds of participants in Focus Group III. The BIM experience ranges from 3 to 5 years. The participants of Focus Group III were selected to explore the thoughts and experiences at the operational level, as Focus Group I and II have represented the strategic and organisational level to some extent.

Table 5: Focus Group III Participants Overview

Focus Group III			
Name	**Discipline**	**Background (Lifecycle Stages)**	**Experience**
Participant A (Par. A)	Mechanical BIM Engineer	Design, Construction	3 years BIM Experience 3 years Field Experience
Participant B (Par. B)	Mechanical BIM Engineer	Design, Construction	3 years BIM Experience 3 years Field Experience
Participant C (Par C)	Mechanical BIM Engineer	Design (Developed + Technical)	4 years Field Experience 4 years Field Experience
Participant D (Par D)	Electrical BIM Engineer	Design (Developed + Technical)	2 years BIM Experience 3 years Field Experience
Participant E (Par. E)	Electrical BIM Reviewer	Design, Construction	5 years BIM Experience 5 years Field Experience

4.2. Flow of Discussion and Moderator Involvement

The level of involvement of the interviewer kept moving from high to low, to high again, according to the dynamics of discussion. Each focus group started with high level of involvement of the interviewer, by giving an introduction to illustrate what is RIBA Plan of Work, and why this research is conducted. The first question was then asked, leading to an unstructured discussion about the potential answers to the asked question. During discussion, the interviewer level of involvement was low, then moved to high by concluding the discussion and moving to the next question. The main involvement of the interviewer in discussion was to clarify any misunderstanding or issues. In some cases, the interviewer had to suggest some ideas from a previous focus group to a current group. This helped to stimulate participants' thinking into finding relevant answers and validates different opinions against each other. A summary of the focus groups settings is presented in Table 6.

Table 6: A summary of conducted focus groups settings

Focus Group	Location	Date and Time	Setting of Interview	Recording Method	Duration
Focus Group I	Virtual Projects	28th August 2017	Meeting Room	Audio Recording	65 min.
Focus Group II	Virtual Projects	30th August 2017	Meeting Room	Audio Recording	62 min.
Focus Group III	Kemet Corporation	5th September 2017	Meeting Room	Audio Recording	78 min.

5. Data Analysis and Interpretation

This section illustrates the findings of research based on the qualitative analysis of focus groups' transcript.

Objective A: The benefits and challenges of integrating the RIBA Plan of Work into construction in Egypt.

The aim was to explore the potential gains of integrating the RIBA Plan of Work in construction practices and Egypt, and the possible difficulties of such integration. Three main themes have been identified.

Table 7 shows the identified common themes through the thematic analysis conducted on Focus Groups' discussion.

Table 7: Qualitative Analysis Matrix – Research Question 1

Issue	**Evidence**		
	Focus Group I	**Focus Group II**	**Focus Group III**
RIBA PoW is not beneficial in its default form for construction in Egypt	"what is the difference between the RIBA Plan of Work, and any other general process for managing project lifecycle?" **Par. A** "each stage should be further detailed as the current is too generic." **Par. E**	"generally speaking, these project lifecycle stages are already implemented in Egypt" **Par. A** "I believe these stages are already there. RIBA is not offering something new." **Par. D**	**"**I think if you ask any developer in Egypt, what will you do to deliver the project? The developer will mention the RIBA Plan of Work stages, but with different terms, as they are the logic sequence of each construction project." **Par. A**

More detailing and guidance is required	"It is required to develop detailed workflows inside each stage of the project lifecycle." **Par. E** "As a development of the current process, the RIBA Plan of Work does not really offer much, as there are neither detailed workflows nor guidelines on how to achieve the high-level objectives." **Par. A** "Enforcing a properly detailed plan of work should organise the process to a great extent." **Par. A**	"The idea is how to execute each stage, either with BIM or traditional." **Par. A**	"There are still many operational problems that need to be addressed, what is the best layout for tower cranes? Which trade should be installed first…etc." **Par. B**
Benefits of integrating RIBA PoW into construction industry in Egypt	"Making entities on the same page." **Par. D**		"Any attempt to standardise practices should be of value in Egypt, due to the lack of published material" **Par. A**
People's resistance to change is a main challenge in integrating RIBA PoW in Egypt	**"**the main challenge is the resistance to change, and the lack of awareness that integrating a standard plan of work will make things easier.**" Par. C, Par. E**	"people usually refrain from taking responsibility of what they have built on-site, because they shared the building process with many different parties." **Par. C**	"the challenges we may face implementing a standard plan of work, is people's resistance to change." **Par. C**

Other challenges of integrating RIBA PoW in Egypt	"another challenge is that each company will understand the plan of work in a different way" **Par. A**	"the "Handover" stage. There is no distinct stage for the handover processes." **Par. A** "this is against the culture here anyways. The handover process implicitly means that you give a guarantee of what you have built on-site, which doesn't really happen." **Par. A**	

Three main patterns of information were identified from the responses of participants:

i. Whether the RIBA PoW is beneficial to the Egyptian construction sector in its default form

Participants of *Focus Group I* and *Focus Group II* agreed that the RIBA PoW does not offer much value in its default form. It was criticised for being too general and lacking real guidance on what needs to be done in each stage. The defined project lifecycle stages are already implemented, but with different terms. In other words, people follow these stages by default, since they are the logical sequence of a building project. For more effective benefits, the plan of work should be used to illustrate how to achieve the objectives of each lifecycle stage, instead of just providing an indication of what needs to be done. Participants of *Focus Group III* did not explicitly provide the same statement. The benefits they have identified were related to the benefits of standardisation of process in general, not the benefits of the RIBA PoW in particular. In addition, the identified benefits were driven by the fact that there is no published material related to project lifecycle management in Egypt. Therefore, any attempt to standardise the process would be of benefit. Integrating a standard plan of work into construction sector in Egypt should provide a better management of the initiation of each stage by aligning all project stakeholders to the same terms, tasks and overall plan. This should help minimise conflicts between project stakeholders throughout its lifecycle. In addition, it is a good start to unify organisational and operational practices and standards, as they are a reason of much rework, because currently they are subject to the different opinions of individuals. This can be interpreted as a consensus agreement that the RIBA PoW is not beneficial for the construction sector in Egypt in its default form, but it can be if it is more detailed and more related to BIM. Participants from all focus groups suggested that the RIBA PoW should provide more guidance and details on necessary BIM activities in each stage. There was an emphasis on the importance of developing detailed workflows and plans of work on both the organisational and operational levels. This places more credibility on the significance of research objectives of integrating BIM activities into the RIBA PoW, and that any developed plan of work should be integrated with detailed description of BIM activities.

ii. People's resistance to change is a main challenge

There has been a consensus agreement among all focus groups that the main challenge facing the integration of the RIBA PoW is the people's resistance to change. The resistance to change is mainly due to lack of awareness and sticking to old methodologies. Suggestions have been made to overcome resistance to change through mandating policies and education/training activities. For an effective integration of the RIBA PoW in Egypt, it must be published by an authoritative body, who will take the responsibility of encouraging and enforcing in some cases- construction companies to adopt the published standards. People will usually try to avoid any additional constraints, even if these constraints were to their benefit. This can be solved by educating people about the benefits of such changes and rewarding those who adopt the change.

iii. The difficulty of the explicit implication of the Handover stage

The challenges of integrating the RIBA Plan of Work in Egypt are mainly related to the Handover stage. The handover is not considered as a stage in Egypt, but rather it is a concurrent activity with the construction stage. The handover stage is generally against the nature of projects in Egypt. A handover implicitly means taking the responsibility of what has been built in the construction site. The handover process is usually divided into many stages over a long period of time, which distributes the responsibility of constructed objects over many entities, which makes it difficult to account a single entity for discovered construction flaws. Hence, people usually refrain from taking responsibility of what was built on site, making it difficult to impose a distinct handover stage. Despite this is the case in most governmental projects, it is not applied to certain building types such as hospitals.

Objective B: The integration of BIM activities into the RIBA Plan of Work.

Objective B aimed to explore how to develop a BIM-RIBA Plan of Work. Data were collected to achieve objective B using two questions. First question is related to identifying strategic BIM objectives, based on the difficulties of each stage using traditional methods. The second question is related to identifying main BIM deliverables at each lifecycle stage and describing model progression using level of detail (LOD). This section illustrates common patterns that occurred during the discussion. Refer to section 6 for information on the identified BIM objectives, activities, deliverables, the developed BIM-RIBA PoW.

Table 8 and Table 9 show the identified common themes through the thematic analysis conducted on Focus Groups' discussion.

Table 8: Qualitative Analysis Matrix – Research Question 2 & 3

Issue	**Evidence**		
	Focus Group I	**Focus Group II**	**Focus Group III**

BIM objectives and challenges in Strategic Definition stage.	"I don't think BIM can do much at these stages. However, the decision to adopt BIM in the project at this stage should impact the project budget. It will not probably affect his project objectives and outcomes." **Par. A** "I think BIM is related to this stage only as a cost parameter." **Par. A**	"I don't believe BIM can do much at these stages. BIM cannot provide something at the Strategic Definition stage" **Par. A** "there should be special preparation if BIM is implemented. BIM is an additional preparation task in this stage, to start using BIM in the coming stages." **Par. A**	"we can use data from previous projects that have been constructed using BIM. All documents, discrepancies and the lessons learnt." **Par. A** "but other companies in Egypt will not share such information." **Par. B**
BIM objectives and challenges in Preparation and Brief stage.	"I believe the role of BIM at the first two stages should be just awareness of the concept to the people in charge." **Par. D**	"I think the objective of BIM at the Preparation and Brief stage and Concept Design stage should be focused on cost estimate." **Par. C** "Preparation and Brief stage is related to generating information about the project and collect information about site conditions." **Par. B** "this means that decisions are made based on back and forth movements between Concept Design stage and Preparation and Brief stage." **Par. D**	
BIM Objectives and challenges in Concept Design stage	"Visualisation is very important at this stage" **Par. A** "BIM should also help in the LEED subject. It should enable the	"approximate estimate of the energy consumption of the building." **Par. B** "you can derive a rough cost estimate from the	"using 3D visualisations. It should be easy to virtually navigate and walk through your model." **Par. B**

	designer to do more realistic energy analysis." **Par. D** "at this stage, the architect starts to design the building spaces, which will be shared with MEP consultants at a later stage. BIM should make it easier for the architect to consider their constraints, by designing in 3D." **Par. A** "visualisation at this stage will be real, and not just rendered shots, which will enable timely cost decisions." **Par. A** "designer can also relate to the cost placed on the project. A parametric concept model can be used to get a rough -but more accurate- estimate of project cost." **Par. D**	building mass at this stage." **Par. C** "I believe the biggest issues in design stages is the lag in involving other disciplines in the concept design" **Par. A** "When the architect creates the concept design, does the building end up to the same shape defined in the concept design? Mostly no." **Par. A** "concept design should be at LOD100." **Par. A** "the problems are the concept design in architecture is different than that in MEP." **Par. B** "If other disciplines started to engage with architect in early concept design stage, he can consider their requirements, especially space-related requirements." **Par. A**	"Using BIM, the owner should be more able to see the design intent." **Par. A** "The major problem is that there is no interface between the architect and other disciplines." **Par. C** "BIM can be useful in estimating rough project cost at this stage." **Par. B** "Concept Design stage for visualising design intent to the owner, should help minimise changes from the owner side in later stages" **Par. D** "interfacing other disciplines with the architect at the Concept Design stage, should help minimise changes" **Par. D**
BIM Objectives and challenges in Developed Design stage	"it is a must that the design is coordinated!" **Par. D**	"after that, the developed design should be from LOD200 to LOD300" **Par. A** "Other disciplines usually cause a lot of delay when they begin to be	"facilitate the coordination between different disciplines." **Par. A** "it depends, say LOD300." **Par. A**

		involved at this stage" **Par. A**	
BIM Objectives and challenges in Technical Design stage	"so, it will be a matter of adding non-geometric information only" **Par. E** "Technical Design stage should be only about adding procurement information." **Par. A** "talking from real world perspective, this is the most complicated stage. This is because the previous stage (Developed Design) did not produce outputs with the required quality that the next stage (Construction) is expecting." **Par. D**	"the Technical Design stage should be for enriching this BIM model with additional information." **Par. E** "the BIM model must contain information about construction sequence, and the site team should be committed to this sequence." **Par. E**	"service areas should be of LOD400 in the Developed Design stage. Services areas like electric rooms, pump rooms, chiller rooms…etc." **Par. D** high level of detail is not necessary at all." **Par. B**

BIM Objectives and challenges in Construction stage	"The nature of issues at the Construction stage is mainly related to the site conditions" **Par. A** "regulations, site conditions, supply chain capabilities. These are the main concerns of this stage." **Par. A** "The complications at this stage are mainly related to inaccuracies and wrong assumptions from the site team." **Par. A, E** "BIM should be of aid to this problem, by enabling the site team to navigate and walkthrough the BIM model for a better understanding." **Par. E** "currently, this stage is way too far from BIM. Eventually the engineers on-site will use 2D drawings that he can understand." **Par. C** "the BIM model could act as additional information to the printed drawings. The site engineer will get the 2D drawings -which he is used to build from- and will have ability to navigate through the BIM model, if he needs	"The problem is that most client demand an LOD500 as-built model, based on the current LOD standards. This is not applicable, as the effort to do so is extremely big." **Par. D**	"this will prevent the "missing information" problem." **Par. B** "integrating construction sequence with material and equipment procurement." **Par. E** "the main objective at this stage will be site coordination." **Par. B** "COBie parameters into BIM construction models for facilities management." **Par. A** "for sure, a 4D model." **Par. A** "level of information. Increasing the level of detail would not be of a tangible value." **All** "I may need to increase the graphical level of detail for a client presentation or visualisation demonstration. It is a big effort, and of no value for construction of facilities management, however, it usually impresses the client." **Par. A**

	to clarify something that isn't displayed properly in the drawings." **Par. E** exactly, you lost all the value and effort that has been implemented in the previous stages, even if BIM has been implemented properly. The BIM model usage should be extended to this stage. **Par. C, E** "The design team should be available as a support, rather than considering the design work is done once the shop drawings have been issued." **Par. A** "The procurement process should be integrated with the construction sequence, and the BIM model should contain coordinated information for both procurement and construction sequence." **Par. A, E**		
BIM Objectives and challenges in Handover stage	"the handover process takes place on several stages. There are handover processes for the installed/built items as per each trade, in each zone, then there is a handover for complete systems." **Par. A** "I don't believe BIM can	"maintenance information should be integrated into the BIM model at this stage." **Par. E**	

	offer much at this stage." **Par. D** "the handover process takes place on several stages. There are handover processes for the installed/built items as per each trade, in each zone, then there is a handover for complete systems." **Par. A**		
BIM Objectives and challenges in In Use stage	"which is the model can be integrated with FM information database." **Par. A**	"there should be a 3D model-based facilities management software" **Par. B**	
Challenges of developing coordinated design in Egypt	"another big problem is that people working in the project are usually not qualified. People who are applying the BIM theory are not qualified to apply it, from the very high-level process to the very detailed production workflows. So, even if the process is mature, there is a big problem in the people working in the process." **Par. C** "add that the experience of people at this stage is based on their work in traditional projects, so they do not have the sufficient knowledge and collaborative skills to produce a coordinated design." **Par. C, D, E**		"I believe the current problem of coordination is not the tools or the software, but people. Most of staff in engineering companies coordinated based on their experiences in previous traditional projects." **Par. E** "people are not educated to do that properly, especially in engineering companies." **Par. E**

	"yes, even in current BIM projects the design is usually referred to as a combination of calculations and schematic drawings, with no reference to any coordination." **Par. B** "this moves us to the same point, which is there is no policy to enforce the designer to produce a coordinated design." **Par. D** "I am required to do the coordination in the construction stage under the pressure of the concrete pump in site." **Par. A**		
Sustaining BIM models for usability throughout project lifecycle	"the same developed BIM model can be further detailed at later stages, making working in the project incremental." **Par. B** "The developed design model is usually scrapped, and the technical design model is built from scratch. The developed design model is used only as a reference for the design concept, however, it cannot be used for further detailing and coordinating." **Par. B**		

LOD definitions refinement	"current LOD definitions are vague to some extent." **Par. C, D**	"you cannot say that a whole LOD standard is practical or not. There are some parts that are not practical, and other parts that work perfectly fine." **Par. A** "This level of detailing is not of any benefit in design, construction or facilities management stages. You don't that level of geometrical detailing." **Par. D** "especially considering the scale of buildings in the Middle East." **Par. A, B, D** "for us in the MEP, what we need is just the space that the element occupies in space. I don't need that high level of geometrical detail. I don't to see the bolts, the buttons, and fixation hinges at each element in the model. I can compensate that graphical detail by increasing the level of information." **Par. E** "it is not the same case in architecture, as architecture is more about visuals." **Par. A** "the increase in the level of information should be of help, unlike the	"Usually, information requirements identify a certain LOD at each stage, e.g. LOD300 in the Developed Design stage. However, there are some zones inside a building that will require a higher LOD." **Par. A** "It should indicate, in more detail, the LOD required at each stage, and it should be obligatory to all project stakeholders." **Par. C** "But for bigger projects, the current BIM software is unable to achieve that graphical level of detail." **Par. A**

		increase in geometrical detail." **Par. B**	

Table 9: Qualitative Analysis Matrix – Research Question 4

Issue	Evidence		
	Focus Group I	**Focus Group II**	**Focus Group III**
Requirements and challenges of early Engineering integration	"the developed design." **Par. A, D** **"**a more informed client should be able to properly manage the whole process.**"** **Par. A** "I believe the most difficult thing to do, is to convince the contractor to invest more money and time at an earlier stage," **Par. E** "two stages should be related only the owner / developer. The contractor should be involved in the project from the Developed Design stage." **Par. A, D**	"in the Concept Design stage." **Par. A** "the architect should visualise the building shape and characteristics, and other disciplines should inform him about the engineering requirements that will be integrated with his design." **Par. B** "I think it is somewhere between the end of Concept Design stage and the start of Developed Design stage." **Par. A** "BIM usually starts in the Developed Design stage." **Par. C**	"I believe in the Concept Design." **Par. D** "I believe in the Developed Design stage. The problem in Egypt is that the project is never designed by a single entity." **Par. B** "I think the sub-consultants should be engaged in the beginning of the Developed Design stage." **Par. A** "Engineering must provide their consideration - especially related to space requirements- to the architect so that he can implement them in his concept design." **Par. C**
Requirements and challenges of early Contractor integration	"in design-bid-build projects, the process is totally separate, so you cannot have a contractor in the design stage." **Par. A** "It is considered as an additional cost to involve the construction team in early design stages." **Par. E**	"I think the contractor should begin to be involved from early Developed Design stage." **Par. A** "simply because design and construction are two distinctive things." **Par. C** "we can answer the "why should I get involved in developed	"BIM is usually implemented in the design stage (usually the Developed Design stage), ending in traditional methods in the construction stage" **Par. D**

	"The delegated team should clarify to the construction team what is the usual sequence of installing building elements." **Par. B, C** "refer to construction sequence as the statement of method, which indicates how the building is constructed." **Par. A** "construction sequence in early design stages can drastically minimise the most difficult stage" **Par. D** Under client pressure, the contractor does not have the culture nor the patience to invest time at the beginning of the Construction stage, in order to provide a better product quality. **Par. C** "yes, the contractor should provide the consultant with construction sequence, to get his design approved." **Par. B**	design?" question by giving the contractor certain fees on his involvement." **Par. A** "The contractor hires a consultant to do the design, but does not get involved until the very end of the Developed Design stage. This is the culture here in Egypt, and I believe in many parts of the world" **Par. A** "If the contractor earns all his profit from construction, why should he get involved in a different stage?" **Par. A**	

Three main patterns of information were identified from the responses of participants:

i. Achieve integration between stakeholders throughout project lifecycle

Several BIM activities have been identified at each stage in the RIBA PoW lifecycle stages. However, they all seek to achieve a common goal. The implicit goal of identified BIM activities is achieving integration between project stakeholders throughout its lifecycle. The use of parametric design models, 3D visualisation, virtual reality (VR) and 3D laser scanning have been frequently mentioned as collaborative tools, which are able to achieve integration between owners, consultants and contractors. Examples include developing parametric design models to reflect cost information, and VR models to visualise design intent for decision makers. This should achieve integration between the owner and architect, in concept design and preparation & brief stages. It has been acknowledged that BIM benefits are still unrecognisable in the stages related to business i.e. strategic definition. All participants of the three focus groups argued that it is imperative that the desired integration takes place as early as possible to be effective. Late involvement of other disciplines usually extends the design stage duration. Eventually the architect will have to satisfy the requirements of other disciplines. This leads to small -but many- changes in the concept design. It was acknowledged that current practices and mindsets in the field form challenges that would inhibit such integration. The project manager or the client should be aware of the benefits of such integration and enforce other stakeholders to share such information. Suggestions have been made to overcome these challenges. However, it was also acknowledged that these suggestions cannot be effective without the presence of mandating governmental policies and more informed clients.

ii. Teaching design coordination

Developing a coordinated design is one of the identified BIM strategic objectives. Most participants acknowledged that developing a coordinated design is a major challenge in Egypt. Participants stated that the common culture in Egypt is that design coordination is the responsibility of the contractor, even in projects with BIM implementation. Eventually design coordination takes place in the construction stage, leading to much rework, costly design changes, conflicts and a low-quality product. This is the opposite of what the core objective of BIM, which is shifting the peak of information generation into the early design stages (MacLeamy 2004). Moreover, it was mentioned that people in design firms lack the necessary collaboration skills to manage design coordination. This can be interpreted that practitioners in design firms practise collaboration in BIM projects based on their previous experience from traditional projects. Hence, there should be educational and awareness activities to practitioners in design firms about the development and management of coordinated design. The desired coordination is not mainly related to clash detection. The term "clash-free" model is being marketed as a synonym for coordinated design, although clash detection and clash avoidance are considered to be an integral part of the BIM process (Designing Buildings Ltd. 2017). A clash-free design model can still contain many buildability and maintainability issues that can change the concept design. This emphasises the necessity of early integration of contractors in the design process, due to the lack of knowledge related to buildability in design firms. Worth to mention that the teaching of coordinated design theme was identified in *Focus Group I* and *Focus Group II*, whose participants were mainly of mechanical and electrical engineering backgrounds, unlike the participants of *Focus Group III* which comprised participants with architectural and BIM consultancy backgrounds. This can be interpreted to acknowledging that MEP disciplines are the most affected by uncoordinated designs. An identified sub-theme related to teaching design coordination, is the sustainability of project information model for reusability throughout project lifecycle. Current practices imply scrapping design models of each stage and starting the modelling processes from scratch. Developing a coordinated design should significantly sustain the project information model, to be reused in technical design, construction and in-use stages, since that these carried out tasks in these stages would be enriching BIM models with non-graphical information.

iii. Refining current LOD definitions

All participants argued that the current LOD definitions needed more refinement. The current LOD definition standards contain many flaws and are not really applicable in real world. A common pattern was identified in all discussions. There was a consensus amongst the focus groups that it is impractical to reach the highest level of geometrical detail in construction and as-built models. As an example, most LOD standards indicate the as-built models should be of LOD500, which represents the maximum level of geometrical detail and information. It was acknowledged that the exerted effort is too big compared to the value gained from such graphical detailing. The graphical level of detail of an element should stop at the level that shows how much space an element occupies in space, without further detailing of how that element looks in real life. Suggestions have been made to describe the progression of iLod of design elements independently from eLod, throughout project lifecycle stages. In MEP disciplines, after a certain eLod (identified to be eLod350, based on AIA definition), the increase in level of detail can be compensated by an increase in the level of information. Architectural elements' eLod can be increased to reach realistic level of detail (eLod500) in front of house areas, for the sake of visualisations only. Participants of *Focus Group III* indicated that achieving the level of graphical detail of LOD500 is not possible using current software and hardware capabilities, as it will cause severe performance issues.
As a conclusion, it is not practical to apply a single LOD definition to the whole building model. The LOD definition should be on the level of building model elements, and should relate to the element zone, discipline and the current project lifecycle stage. In addition, generally the graphical level of detail should stop at eLod350, while the level of information should reach iLod500.

Objective C: The integration of BIM-RIBA Plan of Work over traditional project lifecycle stages in Egypt.

Two main themes have been identified. Both table structure and process map structure should be used, and there must be a tendering stage in project lifecycle.
Table 10 shows the identified common themes through the thematic analysis conducted on Focus Groups' discussion.

Table 10: Qualitative Analysis Matrix – Research Question 5

Issue	**Evidence**		
	Focus Group I	**Focus Group II**	**Focus Group III**

Table structure vs. process map	**“**process map is better in describing the information flow and roles, however, the table structure is better describing what needs to be done at each stage, regardless of who will do it. So, an effective plan of work should include both.**”** **Par. C, D** **“**both structures offer different levels of detail.**”** **Par. B**	“you cannot use only one, both must be used.” **Par. A** “I believe that the process map is better, because the table structure is unable to illustrate tasks which are carried out in more than one stage.” **Par. D** “the table structure is useful in describing what needs to be done in general. The process is more detailed.” **Par. E**	“I believe there should be some combination between both structures” **Par. E** **“**owner management does not need more than to know what needs to be done at each stage, and therefore, the table structure is suitable for them.**”** **Par. A**
Procurement task vs. tendering stage	“procurement to be an activity. Just as planning, it is an activity that is carried out and updated several times throughout project lifecycle.” **Par. A, Par. D**	“For example, the government in Egypt does not allow tendering projects using direct order procurement. Such regulations require that tendering becomes a clear stage with a start and an end.” **Par. A**	“I think it is better to be stage, with a clear start and end. Contractors are usually not straight forward, so there should be stage where a price is settled.” **Par. E**
RIBA PoW stages vs. Traditional project lifecycle stages in Egypt	“I would add the pre-construction stage.” **Par. E** “should be a stage acting as a quality gate between Developed Design stage and Technical Design stage.” **Par. B**		

i. Both table structure and process map structure should be used

The table structure of the RIBA Plan of Work is not a substitute to the process map. Both structures should be used as contractual documents, since both of them are used to describe different levels of detail, and different levels of management. The table structure should serve as a general description of what needs to be done, which is suitable for the management representing the owner or the developer. The process map is more advantageous in describing the information flow between project stakeholders, and their responsibilities.

ii. The necessity of the presence of a tendering stage in project lifecycle
Including procurement as continuum throughout project lifecycle is more beneficial due to the current economic condition in Egypt. However, current regulations and practices in Egypt imply the presence of a tendering stage with a clear start and end. Distributing procurement on packages throughout project lifecycle is only applicable in design and build projects. A conclusion can be made that a single structure of project stages cannot fit all procurement routes.

Objective D: Recommend future research opportunities

Table 11 shows the identified common themes through the thematic analysis conducted on Focus Groups' discussion.

Table 11: Qualitative Analysis Matrix – Research Question 6

Issue	**Evidence**		
	Focus Group I	**Focus Group II**	**Focus Group III**
More in-depth research	"I believe the research should focus on the operational level, moving up to strategic level, not vice versa." **Par. A** "the current problem is that despite there is an abundance of information related to strategic management, there is still so much to explore in the organisational and operational levels." **Par. C** "yes, there should be a research on linking the engineering modelling processes to the construction sequence" **Par. D**	"I believe the areas you mentioned are very high level. There should be more research on lower levels." **Par. B** "yes, future research should go in-depth into a specific subject, instead of doing a research on very general subjects." **Par. A** "However, they are all theories, and there is a lack of information of the methodologies of implementing these theories." **Par. B**	"I believe there should be more research on how BIM would be beneficial for business. I haven't seen that." **Par. B** "I believe that there are more research areas to be explored in the construction stage with BIM." **Par. E** "developing a constructible design using BIM is one of the most critical subjects, that lack the required research." **Par. C** "clash-free term is being marketed as a synonym for coordinated design. However, you can

			receive a clash-free model that has many constructability issues." **Par. C** "For example, facilitating the communication between the site team and technical office." **Par. B**
More educational activities	"People in the industry must be properly educated not just trained on the BIM software" **Par. B**	"people with design background are usually totally unaware of constructability issues, which causes many troubles at the Technical Design stage." **Par. A**	"educate BIM to people in management, and how to convince them with the benefits of implementing BIM in their projects" **Par. A**
More collaboration between academic research and industry pioneers		"the "how" part will not probably get achieved based on studies. Industry practitioners must validate these theories in real-life projects, and provide feedback." **Par. D** "there should be a lot of case studies, related to the subject of early engagement of consultant and contractor." **Par. B**	

i. More focus on the "how" instead of "what"

Through participants' feedback, the discussion explored the "how" part of achieving the integration of project stakeholders. A common theme has been identified among all participants, which is that people in the industry are fed with researches about BIM definitions, BIM benefits, BIM adoption dynamics and what you can do with BIM. Instead, what the industry currently needs is to focus the research on "how" instead of "what", since theoretical frameworks are not enough to improve performance. More research is required on BIM education, better methodologies and best practices, providing in-depth insights upon improving organisational and operational processes. While the "how" part of the research should be conducted by companies in the field, the research process is slow, and not shared to everyone, in addition to not following the scientific research methods. Hence, future collaboration between academic research and practical field is significantly recommended. Eastman, Teicholz et al. (2012) argued that new BIM workflows will stem from trial and error efforts by industry pioneers. *Figure* 4 depicts different levels of BIM processes based on the firm model by Langford and Male (2001).

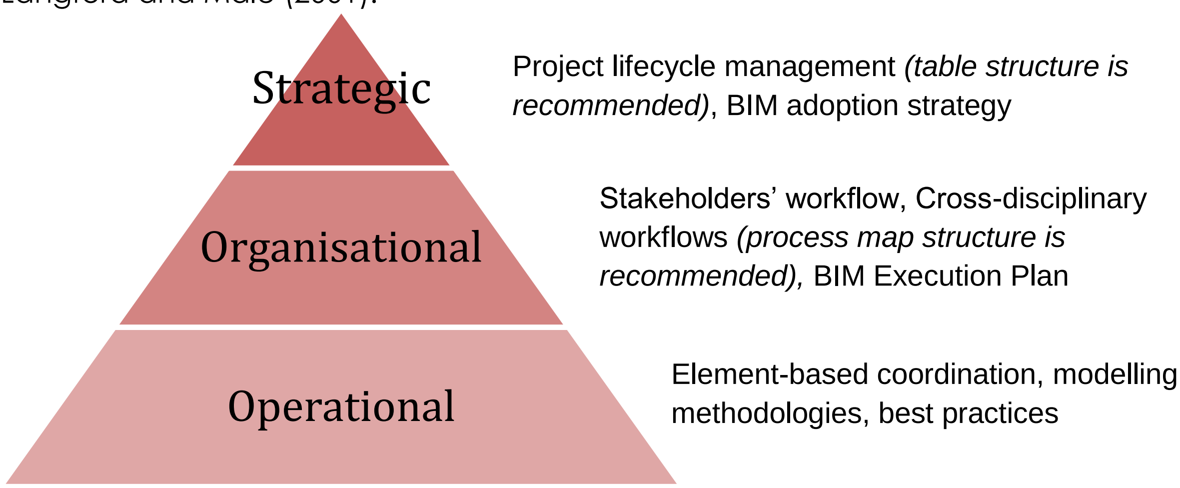

Figure 4: Different levels of BIM processes

ii. More interoperability between BIM tools

Future research on BIM applications should focus on facilitating the communication between project teams, especially during the construction stage. Furthermore, more research is required on the interoperability between current BIM software, used in the design and construction stages, and the software used in facilities management stage. As a conclusion, more integration is required between modelling software, and the software used for design calculations.

6. Proposed BIM-RIBA Plan of Work for Egypt

This section explains the discussion made on the identification of the main BIM objectives of each stage in the RIBA PoW, activities, deliverables and recommended educational activities. The section is then concluded with 7 which depicts the integration of BIM activities with the RIBA Plan of Work.

Strategic Definition: There has been a consensus acknowledgement that current BIM knowledge cannot do much at this stage. However, the decision to implement BIM in a project should be considered as a cost parameter at this stage. BIM implementation should be considered as an additional preparation. The role of BIM at this stage should be only awareness activities to the people in charge. The awareness activities should be oriented about the real benefits they should expect, and when they should begin to see them.
It has been suggested that BIM should facilitate the ability to collect quantitative data from previous projects. However, there has been an acknowledgement that most companies in the construction industry in Egypt are not willing to share information about their project experience. However, a single company can make use of previous projects history.

Preparation and Brief: Site conditions can significantly impact the concept design, and subsequently, impact project feasibility study. Hence, BIM should be used at this stage to model site conditions and integrate this model into the concept design stage. This implies many back and forth movement between the concept design stage and the preparation and brief stage. Hence, it is recommended that both stages are merged into a single stage (See *Figure 5*).

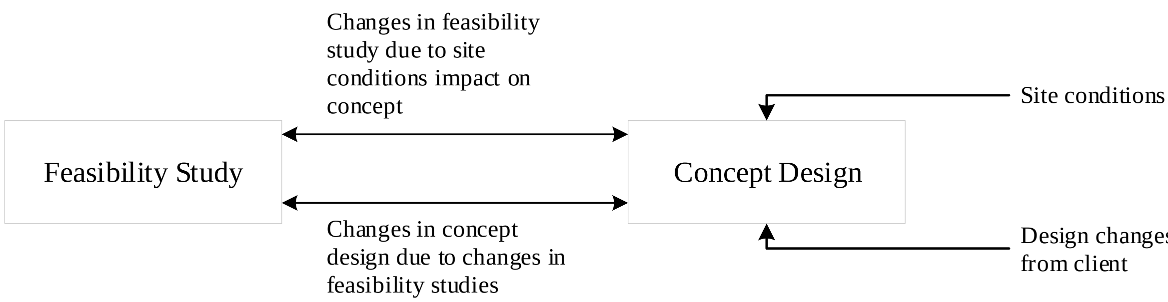

Figure 5: diagram showing the reason why the Preparation and Brief and Concept Design should be one stage

Concept Design: The main BIM objective at this stage is to facilitate the communication between the designer and the client. Visualisation of design intent at this stage should help obtain clear design decisions with minimum impact on project budget and duration. Considering the large scale of buildings in Egypt and the GCC countries, VR model can be developed only for the front of house areas. BIM should also enable the integration of industry-standards cost information into a parametric concept design model. Site conditions and supply chain capabilities should be integrated into the project as early as the concept design stage. Another objective is to facilitate the involvement of other design disciplines in the concept design stage. The architect should be provided with the engineering requirements to be considered in the concept design. Cost information should be obtained from a parametric design model that is integrated with history cost information from other projects.

Developed Design: The main problem in the developed design stage is that the resulting design model is not coordinated. The main objective of BIM at this stage is to facilitate the development of a coordinated design model. While people already work in a 3D collaborative environment, they lack the knowledge and skill to collaborate effectively. Their collaborative work experience is based on their previous work in traditional projects. Moreover, the training they receive is usually related only to software skills. Most often, the resulting developed design model is not reusable for the following stages. Hence, the model is implicitly redesigned, but with more timetable pressure. The non-usability of the developed design model is mainly because of poor cross-trade coordination during design progression stages. While current BIM software provides the tools necessary to do cross-trade coordination, people at this stage use their experience from traditional projects to do the coordination in BIM projects. The common culture in Egypt is that the contractor is the entity responsible for the coordination, and the designer is only responsible for calculations and 2D layouts. Hence, the BIM model is developed using the same workflows and methodologies of traditional projects. Thus, what needs to be addressed at this stage is how to change this mentality into more collaborative workflows. Another issue usually faced in the developed design stage is the vague definition of the Level of Development of BIM models.

***Technical Design**:* Technical Design is considered the most complicated stage in the whole project lifecycle. Based on the quality of the developed design stage output, it could be just a stage of integrating supply chain information, or it could lead to an implicit redesign of the whole building. The redesign process usually occurs due to the existence of many coordination and buildability issues that have not been considered in the developed design. In addition, in most design and build projects, this stage overlaps with the construction stage, making the redesign process under the pressure of concrete pumps and project timetable. This eventually leads to low quality output and many site-based decisions that heavily impact the performance of the building. Technical design stage should contain sufficient information about construction sequence and construction methods. Moreover, BIM should facilitate the coordination between procurement plans and construction sequence (4D model).

***Construction**:* The main complication at this stage is that BIM practically ends before it. Most site engineers and workers still depend on printed shop drawings to perform building and installation processes. What happens is that printed drawings usually do not contain enough information and shows only information related to a single trade. This leads to many questions at the site team, on why certain things are built in certain way and not the other. Subsequently, this leads to many debates between the site team and technical office, and -in many cases- on-site design change decision. The main objective of BIM at this stage is to provide a platform that enables the site team to navigate through the design model, place mark-ups, comments and obtain clarifications on real-time basis. In addition, BIM should be of great help to manage site logistics and storage, by integrating 4D models with procurement requirements and constraints.

***Handover**:* There has been a consensus agreement that there is no specific task for BIM at the Handover stage. The Handover stage is considered as a preparation for the in-use stage. However, there should be a "lessons learnt" stage at the end of each project, in which BIM should help translate project successes and failures into measurable numbers.

In-Use: Currently COBie is the common deliverable in the In-Use stage; however, it would be better to integrate COBie into a 3D model using a 3D model-based FM software. There is currently some Facilities Management (FM) software systems that are 3D model-based, however, there are still many interoperability issues between them and the BIM software used in design construction (See Table 11).

Table 11: BIM-RIBA Plan of Work

	0 Strategic Definition	1 Preparation and Brief	2 Concept Design	3 Developed Design	4 Technical Design	5 Construction	6 Handover and Close Out	7 In Use
Strategic BIM objectives	• Collecting data from previous projects.	• Project feasibility study. • Updating assigned budget based on concept design changes. • Definition of 'as-is' condition.	• Facilitating the communication between the owner and the architect. • Validating feasibility study against concept design. • engaging engineering disciplines into architectural concept design. • Prepare sustainability strategy.	• Developing a coordinated design. • Engaging construction team in design development.	• Enriching BIM model with construction non-graphical information. • Engaging construction team in the technical design.	• Facilitating the communication between site team and technical office. • Site coordination, Storage, logistics and labour management. • Maintaining coordinated procurement process.	• Enriching BIM model with FM non-graphical information.	• Learning from project experience.
Core BIM activities	• Develop BIM adoption strategy.	• Develop Employer Information Requirem	• Develop BIM Execution Plan (BEP). • Visualise	• Integrate buildability and maintainability	• Integrate construction sequence into BIM model.	• Updating BIM Execution Plan (BEP). • Integrate	• Integrate COBie information into as-built	• Extract data from BIM models and CDE records

		ents (EIR). • Model existing condition using 3D laser scanning.	design intent to the owner. • Reflect cost information in the concept design. • Perform energy analysis.	consideratio ns into design developme nt.	• Provide Platform to enable site team to comment, inquire and navigate through BIM model.	procuremen t plan with construction sequence. • Provide Platform to enable site team to comment, inquire and navigate through BIM model. • 3D laser scanning of built elements	models.	about overall project performanc e
Main BIM deliverabl es		• Existing condition point cloud model.	• VR models for the front of house areas. • Parametric concept design model including outlines for architectura l, structural and building services. • Preliminary 5D model (cost information model).	• Coordinate d and buildable design model. • Updated 5D model. • Preliminary Bill of Quantities (BOQ).	• 4D model (constructio n schedule information model). • Updated 5D model. • Coordinate d procureme nt plan.	• As-built models. • Simulations of site logistics and construction sequence.	• 6D asset model (facilities managem ent informatio n model). • COBie sheet.	• Quantitativ e data about cost, time, resources… etc.

BIM model LOD definition			• BIM model elements of eLod100 and iLod100.	• BIM model elements of eLod300 and iLod300. • MEP rooms model elements of eLod350 and iLod350.	• BIM model elements of eLod350 and iLod350. • MEP rooms model elements of eLod350 and iLod350.	• BIM model elements of eLod350 and iLod400. • Specific building zones should be of eLod400 for architectural visualization purposes.	• BIM model elements of eLod350 and iLod500.	
Educational activities	• BIM benefits and applications. • BIM business case.	• BIM benefits and applications. • Integrated Project Delivery	• Collaborative practices.	• 3D modelling methodologies and best practices. • Collaborative practices. • Design coordination management.	• Collaborative practices. • 4D Planning.	• Collaborative practices.		
Suggested BIM Software		• Autodesk Recap.	• Autodesk Revit. • Unity. • Autodesk 3ds max. • ProjectWise.	• Autodesk Revit. • Autodesk Navisworks. • Autodesk Glue 360. • ProjectWise.	• Autodesk Revit. • Autodesk Navisworks. • Autodesk Glue 360. • ProjectWise.	• Autodesk Revit. • Autodesk Navisworks. • Autodesk field 360. • Autodesk Recap. • ProjectWise.		

7. Conclusion

This research was conducted to investigate the integration of a BIM-RIBA Plan of Work for delivering construction projects in Egypt. The research aim was achieved through literature review and collecting qualitative data from industry practitioners. Qualitative data were collected through focus group interviews, conducted in Cairo, Egypt. Collected data were then analysed through consecutive stages of audio-recording, transcription, coding, structuring. Analysed data were interpreted using grounded theory approach, into a theoretical framework, depicting the integration of different BIM activities into the RIBA Plan of Work. The devised plan of work was then put into contrast with traditional project lifecycle stages in Egypt to identify the pros and cons of each methodology.

This research explored the opinions of practitioners representing business, design and construction backgrounds. The benefits and challenges of integrating the RIBA PoW in Egypt have been explored. The BIM-RIBA PoW has been devised based on construction practices in Egypt. Focus groups discussion yielded other necessary themes for successful BIM adoption in Egypt such as teaching design coordination, refining current LOD definitions and the necessity of governmental BIM mandating policies. However, as a limitation there has been a difficulty reaching personnel with considerable experience in the facilities management domain. Hence, identified BIM objectives and deliverables are based on the expectations and assumptions of participants representing other domains.

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Appendix 1: Focus Group Questions

The questions from 1 to 6 were used to collect data, based on the research objectives. for information on research objectives:

1. What are the benefits and challenges of integrating the RIBA Plan of Work as a standard construction project lifecycle process in Egypt?
    a. Identify the benefits of integrating the RIBA Plan of Work.
    b. Identify the challenges faced when integrating RIBA Plan of Work into current construction practices in Egypt.
2. What should be the strategic BIM objectives at each stage of the RIBA Plan of Work?
    a. Identify the complications of each project lifecycle stage e.g. the high uncertainty level at the concept design stage.
    b. The solutions to these complications will be identified as the main BIM objectives
3. Based on the identified objectives, what should be the main BIM deliverables of each stage of the RIBA Plan of Work?
    a. How can BIM achieve the identified objectives?
    b. Use LOD to describe BIM model progression throughout project lifecycle.
4. Based on the developed BIM-RIBA Plan of Work, describe the workflow between project main stakeholders? At which stage should each stakeholder be involved, and what should be the contribution?
    a. Introduce Integrated Project Delivery
    b. Based on IPD concept, at which stage should each stakeholder get involved in the project, and to which extent?
5. How can be the developed BIM-RIBA Plan of Work be overlaid over the traditional project lifecycle in Egypt?
    a. Introduce the traditional project lifecycle in Egypt
    b. Put RIBA Plan of Work in contrast with the traditional project lifecycle, and investigate the advantages of integrating both
6. What are the potential areas to be researched in the BIM process field?