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Digital Technology Adoption and Implementation Plan: A Case of the Egyptian Construction Industry

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Abstract

Construction industries are major laggers in adopting new technologies compared to other industries, thus efficient delivery of projects is hindered. Inefficiency in construction project delivery became acute during the outbreak of the COVID-19 pandemic. Researchers suggest that adopting Digital Technologies (e.g., Building Information Modelling (BIM), Robots, Drones, etc) could have a major impact in mitigating the challenges facing the construction field. Most research unfortunately focused mainly on the benefits of BIM software with less interest on other related; technologies, hardware, standards, procedures, protocols that are essential aspects for a complete innovation. Furthermore, there is paucity of research about how to manage changes associated with the adoption of the innovative technologies by construction firms. This study focuses on developing a Digital adopting plan for a main contractor in Egypt. Data is collected through a quantitative method, where respondents are practitioners who have experience in Egyptian projects. Status of the firm and barriers preventing implementation were dissected from the data-collection. Strategic planning SWOT tool is used to analyze the data and propose strategies necessary for a comprehensive implementation plan. A financial appraisal is then conducted identifying the return of investment to the overall cost. Finally, organizational and project change management plans are proposed for adopting the innovative technologies. This research can update policies that can be used to expand the use of digital technologies specially BIM in practice.

Keywords:

BIM, Construction Industry, Digital Construction Technologies, Covid-19, Return on investment, Strategy Planning

Background

Developing countries have been recognized as a fertile ground for the Architecture, Engineering and Construction AEC industry (Akdag and Maqsood, 2019). Unfortunately, there are crucial challenges facing the construction sector all around the world for the past few years. In addition, the resistance to adopt new methods and technologies have resulted in miscommunication, schedule delay, rework, delay in decision-making (Kudirat and Zulfikar, 2017). The aforementioned challenges have been compounded by the outbreak of COVID-19 outbreak in the early 2020. The virus is known to cause illness ranging from common cold to more severe respiratory diseases (Elibol, 2021). The Los Angeles investigation report stated that construction workers had the highest rate of infection compared to workers of other industries (Jallow, 2020). The most affected countries are far from the end, with harsh policies that faces the potential risk of resurgence in the number`` of infectious cases. Research refers to measures on the use of BIM and management methodologies that can limit COVID-19 spread in complex buildings such as educational buildings, airports or even hospitals (Pavón, 2020). Newman et al. (2020) revealed that in developing nations, construction industry does not have governmental objectives for society and customers, adding that the development of "total projects success" is necessary (Kineber et al., 2021).

BIM is at the forefront of progression. Literature on this technology and its applications are pervasive where the successful strategies in the preliminary and final phases of a project can be addressed (Shirowzhan, 2020). Autodesk (2020) defines BIM as: "A smart 3D model-based approach providing knowledge and tools to design, construct, where it manages buildings and infrastructure more effectively for architecture, engineering, and construction practitioners. BIM has the capacity to increase the efficiency of design, construction, and maintenance of any type of construction project (Pärn et al., 2017). BIM continues to undergo dramatic transformation in response to stakeholders' call for technology to address systemic and recurring challenges that persistently continue. These challenges include but are not limited to; cost, productivity, and time management issues (Oraee et al., 2019). As a method, BIM is aimed at the frequent production process, employing the most effective technology available to boost return on investment (ROI) by means of streamlined and standardised procedures (Azhar, 2011).

Despite the many tangible advantages of this technology, the entire potential of BIM and other digital technologies is probably still to be realised. Many related studies worked on the removal of some clustered barriers that digital technology adoption have witnessed. These studies include identification of current adoption status (Olanrewaju et al., 2020), defining and delineating the barriers in both developed and developing countries by (Babatunde et al., 2019) and (Eadie, et al., 2013). However, there has been very little scholarly attention on the adoption and implementation plan of BIM in practice. Amin and Abanda (2017) and Whitlock and Abanda (2017) are the few studies that brought awareness about the digital adoption plans. However, the focus of these studies have been mostly on BIM with fewer emphases on other emerging technologies such as Robots, Drones, 3D-laser scanners, etc. With the outbreak of COVID-19 that led to the call for widening technological adoption beyond the realm of BIM, is partly due to the fact that some of the

technologies, e.g. drones and robots can aid in minimizing human interaction thereby limiting the spread of COVID-19. Dawrwish (2020) argues that the need for a digital adoption plan is one of the essential aspects of project success, where it is vital for improving the performance of construction firms. Despite the developing countries having a major problem regarding project success, there is no known research in implementing digital technology in the Egyptian building industry. The digital adoption plan saves time and enhance the project quality, with further research, digital technologies can take its path and activities directly from a BIM model (Rafael et. al., 2020). This research can allow decision makers to make a digital choice to cut wasteful expenses and increase the quality of use. This study is important for the Egyptian construction sector, where digital technologies and its implementation is lagging, specifically BIM. As a result, the findings of this study may affect the way in which projects are conducted not only in Egypt, but in other developing countries. Consequently, this research aims to propose a digital adoption plan for a main contractor firm in Egypt. To achieve this aim, 5 main objectives have been set. Firstly, to identify the level of awareness of digital technologies by practitioners. Secondly, to investigate the barriers facing adoption of digital technologies in Egypt. Thirdly, to propose an adoption strategy for digital technology. Fourthly, to conduct an economic/financial appraisal on the proposed digital technology system. Lastly to propose a suitable change management strategy for the digital technologies in construction firms.

Digital Technologies and BIM adoption in AECO firms

A study by Pavón (2020) revealed that due to lack or limited knowledge, contractors have become reluctant to adopting digital construction technologies. It is imperative to choose a suitable procurement route and employ a lifecycle approach as a lens to identify the necessary technologies that should be included in the digital adoption plan.

Procurement routes

Kuiper I. (2021) argued that BIM and procurement are related. In fact, depending on the kind of procurement, different BIM systems are required. Charlson and Dimka (2021) describe the project procurement system as defining the connection between stakeholders in the project and their contribution to the development of the built facility.

There are three main construction procurement routes according to Mesa et al. (2016); design-build (DB), design-bid-build (DBB) and construction management at risk (CMAR). In the traditional procurement method known as design-bid-build (DBB), the client assigns different entities. The designer delivers the design services while a contractor is selected upon winning the bid to construct the project as shown in Figure 1. According to The NBS (2018) report, the traditional DBB procurement is the most dominant method with 46% usage globally followed by (DB) with 41% usage. In this case study, DBB was the type of procurement adopted by Company X.

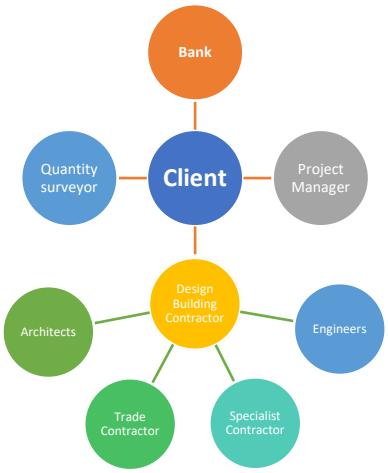

Figure 1. Design-Bid-Build Procurement organizational chart (Davis et al., 2008)

Project Lifecycle

A more systematic approach to identify the technologies required in a project is to use a lifecycle approach. The lifecycle can serve as a lens through which the various technologies are identified in each phase. BIM has been recognized as a major lifecycle management tool that can have a substantial positive effect on a projects' lifecycle (Olanrewaju et al., 2020). With many standards in the field that manages the project's life cycle, for example British standards BS6079-1:2000, Office of Government commerce (OGC), CIOB code of practice for project management and development and The British Property Federation. The Royal Institute of British Architects (RIBA) is one of the institutions that provided a list of BIM activities aligned with the project's life cycle creating the ***BIM Overlay to the RIBA Outline Plan of Work*** (RIBA, 2013). In 2020, The Royal Institute of British Architects modified the old version to RIBA PoW 2020 (RIBA, 2020). The stages are presented in Table 1.

Table 1. RIBA PoW 2020 Stages and Outcome (RIBA, 2020)

Stages	Strategic Definition	Preparation and Briefing	Concept Design	Spatial Coordination
Description & Outcome	Confirming that the building achieves Client's requirements.	Brief confirmed that it can be accommodated on the site.	Architectural Concept approved by the client and aligned to the Project Brief.	Architectural and engineering information Spatially Coordinated.
Stages	**Technical Design**	**Manufacturing and Construction**	**Handover**	**Use**
Description & Outcome	All design information required to manufacture and construct the project completed.	Manufacturing, construction, and Commissioning completed.	Handing over, Aftercare initiated, and Contract concluded.	Building used, operated, and maintained efficiently.

The use of *BIM* and other *digital technologies* may differ on each stage depending on their function and properties.

Classification of BIM and/or Digital technologies

According to literature there are five types of Construction Digital technology application. The first type is the *BIM Software*, this solution for design and construction helps in reducing the on-field clashes resulting in less project delay, over budget and physical interaction. Examples of these software that are most commonly used are Revit, Tekla, ArchiCAD, Navisworks, etc. (Sacks et al., 2018). The *Common Data Environment* CDE is the second type, where it is useful for managing information and lessening physical interaction (Radl, and Kaiser, 2019). Examples of CDE are cloud-computing, BIM 360, Plannerly etc. The third type is the artificial intelligence *AI-based* tools such as *Virtual Reality*, where it can provide a comprehensive vision to all issues inside a construction field without the need of physical presence (Rafael et. al., 2020). *Communication technologies* that can be used in construction industries to decrease face-to-face interaction (Oliveira, 2020), such as Zoom, Skype, Google Meet etc. are considered the fourth type. The last type is the Robotic technology like *drones* or *Robots* that mark their path inside the field and perform their programmed operation, like applying mortar, painting or even brickwork (Rafael et. al., 2020). This technology improves site Safety, minimizing waste, and fosters collaboration.

With these technologies being said, strategic planning must be executed in order to acknowledge which of these technologies are necessary to use and when.

Strategic Planning Method

There are different Strategic planning tools and techniques used for data analysis. These techniques include but are not limited to: SWOT analysis, human resource analysis, Porter's five-forces analysis, financial analysis for own business, value chain analysis, portfolio analysis (growth share), core capability/competence analysis, financial analysis for competitors, scenario construction, analysis of organizational culture, PEST or STEP analysis, analysis of key (critical) success factors, and experience curve analysis (Aldehayyat, 2008).

SWOT analysis is the most useful tool in identifying organization's current status. SWOT is performed after the Data collection section. The internal status of the organization is identified as strength (S) and weaknesses (W), while Enterprise Environmental Factors (EEF) affecting the organization externally is stated as Opportunities (O) and Threats (T). This study will implement the SWOT analysis strategic planning tool. The results from the SWOT analysis along with the data-collection will help in developing strategies that support the innovative framework. In addition, most research studying BIM adoption plans have used The SWOT analysis tool for their data analysis.

Research Methods

The main objective here will be developing a digital adoption plan for a main contractor. The case study contractor firm established in 2003 is located in Mohandessin, Giza, Egypt. Company X's (hidden name for data protection and privacy purposes) staff headcount is between 50 to 70 employees and is considered a small-to-medium enterprise SME firm. Their construction field is oriented towards complex buildings, schools, luxurious housing and industrial facilities. Since it is a construction firm and enters several bids, the company's most frequently used procurement method is Design-Bid-Build (DBB). In order to develop the digital adoption plan for the main contractor, appropriate research methods were adopted.

Firstly, to identify the level of awareness of digital technologies, a questionnaire was used to capture views of practitioners in the Egyptian construction industry.

Secondly, to investigate the barriers facing adoption of digital technologies in Egypt a literature review and questionnaire were used. The former was first conducted which informed the design of the questionnaire.

Thirdly, to propose an adoption strategy for digital technology, SWOT, one of the strategic planning tools will be used to identify the different software required in a digital adoption plan. Building on the identified software, the various related hardware, technologies, personnel required to operate the technologies was established. Fourthly, to conduct an economic/financial appraisal on the proposed digital technology system, and establish economic model created by Autodesk. Lastly a literature review and questionnaire were used to develop a suitable change management strategy for the digital construction technologies.

Results and Discussions

This section will analyze the data dissected from the questionnaire where an adoption strategy, an economical appraisal and a change management plan are proposed based on these data collected.

Awareness of digital technologies in the Egyptian construction industry

Respondents between 5 to 10 years experience where the majority, where only 10% of respondents where not familier with Digital Technologies and BIM, while 71.4% where from moderatly familiar to familier. A large per cent of company X's respondants indicated that their Level of BIM knowlage is good. Most respondants are aware of Digital technologies but only 23.8% have worked in full BIM projects as showen in figure 3.

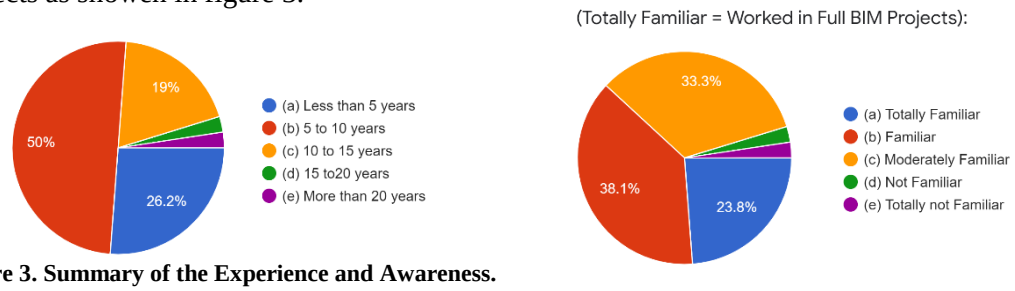

Figure 3. Summary of the Experience and Awareness.

The Collected Data indicate that respondents are aware of *Common Data Environment CDE* stating that BIM360 started to be adopted duering Covid-19 in Egypt than before. Respondents believe that it saves time and cost during construction project but are nuetral regarding its benefits on waste minimization and Collaboration as showen in figure 4. Therefore the full purpose of CDE is not fully acknowladged and implemented in the Egyptian AECO firms, thus no federated information level has been reached. Therefore training and awarness sessions are needed. (Scale 1-5, 1=Totally Disagree & 5=Totally Agree)

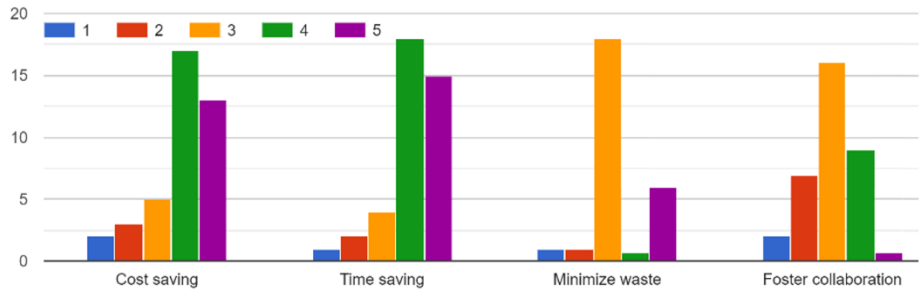

Figure 4. Summary of respondent point of view on CDE

The Collected Data indicate that respondents are aware of virtual communication. Zoom, Skype and Microsoft Team. Tese technologies according to respondents where used more frequently during Covid-19 era than before, where they agree to a high extend that these *Communication technologies* save Cost, Time, and Minimize waste as showen in figure 5. This will be considered in the proposed stratgy section.

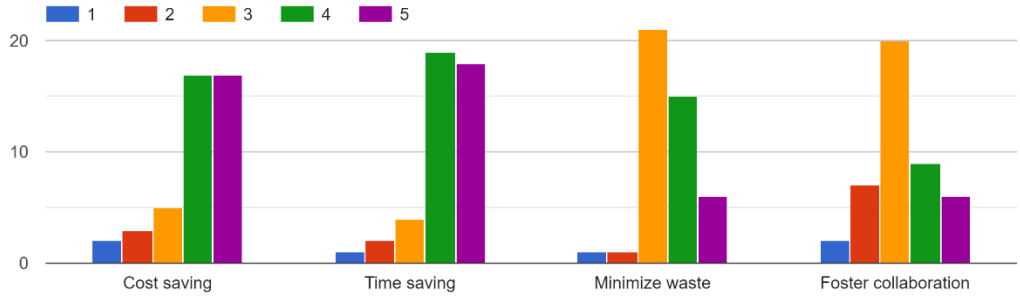

Figure 5. Summary of Virtual communication technology

Respondents stated that they are aware of AI-technology where they mostly agree that AI-Virtual reality AI-VR and live-linked smart devices are adopted more during Covid-19 than before. Unfortunately respondents stated that these technologies do not save cost as showen in figure 6, which is logical due to the government's high import custom fees that can reach upto 400% of the orginal price on the technologies imported to Egypt (ECA, 2021). This will be considered in the proposed stratgy section. (Scale 1-5, 1=Totally Disagree & 5=Totally Agree)

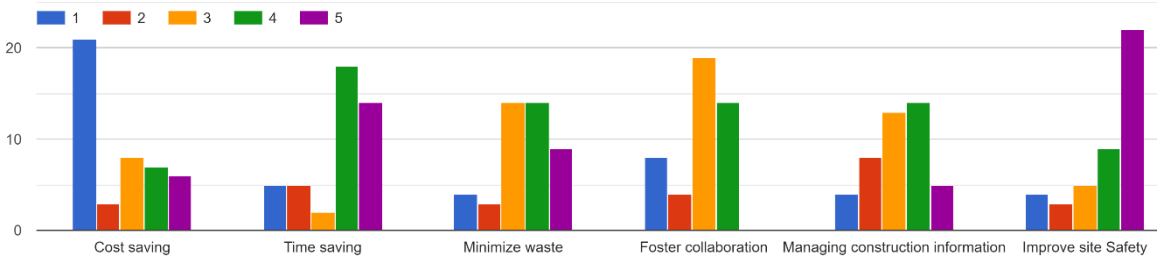

Figure 6. Respondent's point of view on AI-Based technology

Barriers facing adoption of construction digital technologies.

When it comes to barriers that prevent implementation (Figure 7), responses chose 5 key barrier factors which are: Lack of knowlage on how to use them, Limited knowledge about their true potential, Lack of policies guiding their implementation, Upper management resistance, and Poor change management strategy.

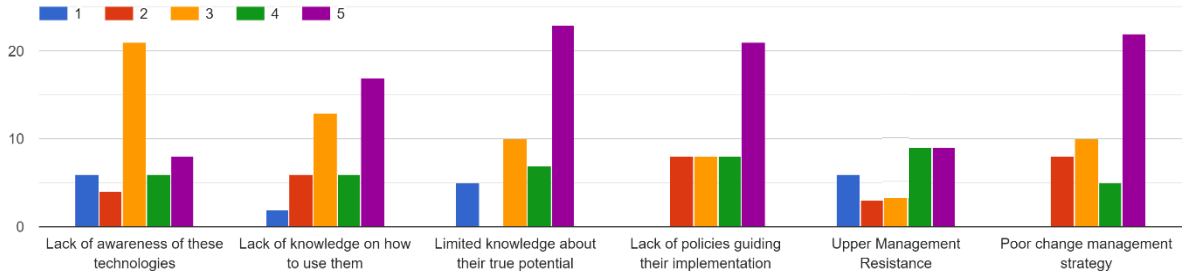

Figure 7. Summary of Barriers from practitioners' point of view

Respondents voted that to comply with the current pandemic construction industries must: Provide more training to practitioners, Develop clear policies, Develop clear management plans, Start using BIM standards.

From these data along with the strategic planning tool chosen (SWOT), a Digital technology adoption strategy can be proposed.

An adoption strategy for Digital Technology.

Implementation of SWOT in identifying issues requiring the need of BIM

SWOT analysis tool analyzed the collected data to identify company X's current status by showing its strength, weakness, opportunities and threats as shown in table 2. Strategies are proposed to take advantages of the strength and opportunities and to eliminate as much as possible threats and weakness.

Table 2: Company x current statues using SWOT analysis tool

Internal Origin	**Strength**	**Weakness**
	S1: Most Professionals are aware of BIM. S2: Company X have a training Department. Stated in its Website on organization hierarchy structure page. S3: They use BIM software, but not the system. S4: AI-VR and smart devise apps were used in small amount since covid-19 than before. S5. Familiar with CDE and have some experience in BIM 360 which they increased its usage during covid-19. S6: Importance of Virtual communication is recognized. S7: Importance of AI-Virtual reality during covid-pandemic is recognized.	W1: Most professionals are unaware of the benefits of digital technologies. W2: They Do not follow any BIM standards. W3: Financially are not capable of purchasing high price AI-Tech due to custom fees. W4: Interaction in meeting rooms spreads COVID. W5: Conflicts between departments due to weak collaboration. W6: Using old 2D overlaying technique in clash detection. W7: Upper Stakeholders resistance to adopt new Technologies stating they do not see the point of learning new technologies. W8: Delay on Field when there are construction clashes. W9: Unaware of CDE's Benefits. W10: BIM stage 2 of Iso-19650 (ISO, 2018) is not reached.
External Origin	**Opportunities**	**Threats**
	O1: Government supports Financially SME Companies in Egypt. (https://www.egypttoday.com/Article/3/98945/Egypt-s-central-bank-obliges-banks-to-increase-financing-directed) O2: There are Subcontractors in Egypt that have adopted BIM.	T1: COVID-19 increases individuals absents to work. T2: Increased TAXs on software. T3: Military AECO Firms are non-faire competitors since TAXs, customs and Employer insurance are Waived from them. T4. Although laws say drones need permission to adopt, Ministry of civil aviation in Egypt will

		never give permission unless used for military purposes (MCAE, 2018) due to current terroristic acts. T5: Egypt collects a huge per centage of custom fees on any machinery or technology imported.

Proposed Strategies:

*Strategy 1***:** S1, S3: Most Professionals are aware of BIM, where they use BIM software, but not the system. Therefore, a BIM examination system shall examine the level of knowledge of each practitioner regarding his/her role then deciding the adequate programs. S2: Company X has a training Department according to its organizational hierarchy on its website; therefore, practitioners do not need to be scattered around training centers thus renting BIM certified training experts with the help of the resources already presented in the training department will be more cost effective.

*Strategy 2***:** S4, S6, S7, W4, W8, T2: Infection spread can be limited with the help of virtual communication, common data environment and smart devices that practitioners began to adopt during Covid-19 pandemic. A well-coordinated protocol collaborating all these aspects should be set to prevent infection spread. Training sessions should be provided to help practitioners learn BIM360, BIM Coordinate and Field in addition to AI-Virtual Reality, with these technologies viral spread will decrease. While the use of smart devices will limit the delay of communicated Data and physical interaction.

*Strategy 3***:** W1, W2, W7, W10, W11: Most professionals are resistant to the ideas because they are unaware of the benefits of digital technologies and BIM. Upper Managers in this case should attend Digital Technology awareness seminars explaining the benefits of these technologies and how they could positively impact the projects and organization. Upper managers should also be trained on how to manage BIM projects, what standards should be used, which is the appropriate protocol to follow, and which is the most suitable strategy to adopt. The training sessions should lead the upper management to be fully qualified to adopt stage 2 maturity level (ISO, 2018). Practitioners in the bottom of the hierarchy should also attend digital technologies awareness seminars to gain a wider perspective on what the training sessions in **strategy 1** is important for.

*Strategy 4***:** S8, W3, T5, T6: Although AI-VR is among the technologies that gained high acceptance from respondent's other technologies like robots are costly and cannot be afforded at the current situation. Whilst drones are prohibited by the Ministry of Civil Aviation Egypt (MCAE, 2018) due to terrorism acts and is highly unlikely to get adopted in current occasions. The best strategy is to adopt AI-VR and Live-Linked smart devices to limit the interaction during the Covid-19 pandemic, where training sessions on their usage should be provided to field inspectors.

*Strategy 5***:** W5, W6: Conflicts, Weak collaboration, and old systems in detecting clashes can be resolved using adequate BIM solution packages that managers and technicians will train for as stated in strategies 1,2 and 3. An appropriate management strategy is set to organize the use of these packages whilst the cost of Hardware, Software and Orgware of these packages will be considered as shown in table 4.

Strategy 6: T3, O1: Although the government applied taxes on software used by firms, most firms can take advantage of the governmental financial support to SME companies in adopting all resources necessary thus increasing organizational revenue instead of termination.

Strategy 7: O2: Many Subcontractors in Egypt have adopted BIM (Amin and Abanda, 2017). The best approach is to replace current subcontractors using old methods with BIM adopters and execute a collaborative framework than will gradually decrease cost, time and infection spread.

Digital technology adoption plan framework

This section presents the hardware, software along with their plugins, and technologies necessary to implement the strategies. The SWOT along with the Digital technology solutions will be presented throughout the stages of RIBA PoW 2020 (RIBA, 2020) as shown in Table 3. The chosen Software should be compatible with one another and should be an Industry Foundation Class (IFC) source. Regarding the training sessions, each job role will have a different training approach.

Although Company X mainly use design bid and build DBB procurement method, they should be prepared in the design phase too, since they get hired in design projects. Therefore, a low amount of personnel will be trained to accomplish activities from stages 0 to 4 in RIBA PoW as shown in table 3. Company X needs upgrades in some of their workstations where the quantity is identifies in table 4. Some BIM software and application are already installed but additional seats are necessary for newly trained personnel for a full stage 2 maturity implementation. A new server with security is needed for a safer information exchange.

Table 3: Recommendations, SWOT analysis, Software, Hardware, and Stakeholders' involvement aligned with RIBA Project Lifecyc

Stages	Challenges identified in SWOT analysis	Recommended Strategies	Software and applications required	Hardware and Technologies Required	Stakeholders involved
0. Strategic Definition	N/A	• Advice appointing party on purpose of BIM including benefits and implications. • Agree on nD Level with appointing party. • Define long Term responsibilities.	N/A	N/A	Client Advisors BIM Manager
1. Preparation and Briefing	T2: Increased TAXs on software (amr et al, 2019)	Defining scope. Develop a BIM Execution Plan BEP. Develop project Program.	Plannerly	Servers	Client Advisors Client Team BIM Manager
2. Concept Design	S1: Most Professionals are aware of BIM. S2: Company X have a training Department. S3: They use BIM software, but not the system. S6: Importance of Virtual communication is recognized. W2: They Do not follow any BIM standards. W4: Interaction in meeting rooms spreads COVID-19 T1: COVID-19 increases individuals absents to work.	**Strategy 1:** • Examine the level of BIM knowledge. • Decide an adequate training for core BIM team. • Hire BIM certified training experts in department. • Set Common Data Environment and data-sharing protocols. • Infection spread can be limited by Virtual communication, common data environment and smart devices. **Strategy 3:** • Set procedures for the companies' training Department.	Autodesk-Revit Enscape (plug-in) Autodesk-Civil 3D Autodesk-Infraworks BIM 360 Documents ZOOM	Visualization workstations for technical team only: - V-Workstation Dell Precision T7910 2x Intel Xeon E5-2698 V4 • 32GB 2400MT/s ECC Memory • Nvidia Quadro M4000 8GB • Samsung EVO 970 500GB NVMe w\ Adapter • 24" Monitor (Multi-core recommended for rendering)	Managers Architects BIM Manager Engineering Advisors
3. Spatial Coordination	S5. Familiar with CDE and have some experience in BIM 360 which they increased it usage during covid-19. W1: Most professionals are unaware of the benefits of digital technologies. W7: Upper Stakeholders resistance to adopt new Technologies stating they do not see the point of learning new technologies.	Strategy 2: • Develop BIM standards based on ISO-19650. • Follow CIC BIM protocols • Update the BEP. Strategy 3: Set vision to adopt stage 2 maturity level then level 3. Strategy 5: • Develop well-coordinated protocols. • Increase awareness of benefits of BIM coordination process.	Autodesk-Revit Insight 360 (plug-in) Autodesk-Civil 3D Autodesk-Infraworks Autodesk-Navisworks BIM 360 coordinate	S-Workstation: •ASUS TURBO RTX 3070 8GB • AMD RYZEN 7 5800X CPU • ASUS B550 Motherboard • CORSAIR 16GB 3600MHz RGB RAM •1TB NVME SSD (Powerful single-core recommended)	Contractor's Design Team Contractor's QS Team Contractor's Planner BIM Coordinators Sub-Contractors Suppliers
4. Technical Design	S4: Navisworks were used in small amount since covid-19 than before. W5: Conflicts between departments due to weak collaboration. W6: Old 2D overlaying technique in clash detection. W9: Unaware of CDE's Benefits. W10: BIM stage 2 is not reached.	•Preparation of 4D, 5D, onwards assessment as agreed which may include Sustainability. •Monitor Data-sharing protocols. •Finalize data to export to appointed parties.	Autodesk-Revit Insight 360 (plug-in) Dynamo (plug-in) Autodesk-Civil 3D Autodesk-Infraworks Autodesk-Navisworks BIM 360 coordinate	AI-Virtual reality S-Workstation:	Contractor's Design Team Contractor's QS Team Contractor's Planner BIM Coordinators Sub-Contractors Suppliers
5. Manufacturing and Construction	S4: Smart devise apps were used in small amount since covid-19 than before. S7: Importance of AI-Virtual reality during covid-pandemic. W3: Financially are not capable of purchasing Robots. W8: Delay on Field when there are construction clashes. T4. Unable to adopt Drones.	**Strategy 3:** •Increase Practitioners awareness level. •Review cost, time, etc: 4D, 5D onwards **Strategy 4:** •AI-VR usage protocols •Smart Devices usage protocols **Strategy 7:** •Hire Sub-contractors that have already adopted BIM.	Plannerly Autodesk-Revit BIM 360 Field Autodesk-Navisworks	AI-Virtual reality S-Workstation: Live-Linked Smart Devices	Contractor's Design Team Contractor's QS Team Contractor's CM Sub-Contractors Suppliers
6. Handover	O1: Government supports Financially SME Companies in Egypt.	**Strategy 5:** •Set meeting with appointing parties to show the success of Digital adoption Plan. •Gather lessons learned for future improvements.	BIM 360 Navisworks	N/A	Client
7. Use	O2: There are Subcontractors in Egypt that have adopted BIM.	•Discuss Lessons learned with sub-contractors for better future project performance and collaboration.	N/A	N/A	Client

Table 4: Economical appraisal of proposed Digital technology adoption plan

Resources	Units	Price E£/Month	Total cost E£	Notes	Purchase Source
Personnel	Not all personnel will be hired, some will convert their current job role after training as will be discussed in Change Management section.				
Implementation BIM manager	2	15,000	30,000		
Project BIM managers	1	15,000	15,000		
Project BIM coordinators	3	12,000	12,000		
BIM legal personnel	1	12,000	12,000		
Information manager	1	10,000	10,000		
BIM modeler	9	6,000	54,000		
Quantity survey QS	2	7,500	15,000		
BIM QC (reviewer)	3	9,000	27,000		
Training	According to data-collection not all personnel require training, Whilst Hiring Certified Expert Trainers is much cheaper than registering for training courses. (There is a Training Department in company X)				
Personal knowledge exam	20	350	7000		
Managerial Level Trainers	1	5,500	5,500	6-weeks Part-time trainer =1.5 month	https://www.solutions-tcc.com/#02
Technical level 1 Beginner- Expert Trainers	1	3,500	3,500	14-weeks Part-time trainer = 3.5 month	https://www.solutions-tcc.com/#02
Technical level 2 Intermediate-Expert Trainers	1	3,500	3,500	8-weeks Part-time trainer = 2 month	https://www.solutions-tcc.com/#02
Quantity survey Trainers	1	4,000	4,000	8-weeks Part-time trainer = 2 month	https://www.solutions-tcc.com/#02
Technological-Field modules Trainers	1	1,500	1,500	1-week Part-time trainer = 0.25 month	https://www.solutions-tcc.com/#02
Awareness Conferences sessions	2	800	1,600		
Software	Units	Price E£/unit	Total cost E£	Notes	Purchase Source
Architecture, engineering & construction collection suite	3	46,000	138,000	• Company X has already adopted Navisworks, but extras are needed. • The package contains all necessary plug-ins.	https://www.autodesk.com/collections/architecture-engineering-construction/overview?term=1-YEAR
Autodesk-Revit	2	35,000	70,000	Company X has already adopted Revit and AutoCAD license but needs extras.	
Common Data Environment CDE					
BIM360 Documents	1	---	----		
BIM 360 coordinate				Already Adopted after Covid-19. (Data-Collection)	
BIM 360 Field					
Plannerly	1	23,500	23,500	Purchase of the Company plan package with BIM360 integration	https://www.plannerly.com/pricing/
Hardware					
Servers	1	42,000	42,000		sales@megabuildupcomputers.com
S-Workstation	3	24,000	72,000	As specified in Table 1	sales@megabuildupcomputers.com
V-Workstation	2	32.000	64,000	As specified in Table 1	sales@megabuildupcomputers.com
Laptops	4	15,000	60,000		sales@megabuildupcomputers.com
Virtual communication					
ZOOM	5	3,150	15,750	Small & Med Business package	https://zoom.us/pricing
Equipment	1	12,350	12,350	Webcams, microphones, and other communication equipment's to implement on workstations and laptops.	
Technologies					
AI-VR Virtual Reality	2	12,800	25,600	HTC Vive Cosmos Elite Virtual Reality System, for site managers	https://www.amazon.com
Live-Linked Smart Devices	4	3200	12,800	Samsung A7 10-inch Tablets with CDE apps installed, for site managers	https://www.amazon.com
Developing BIM standards	-	22,000	22,000		
Developing BIM Library	-	15,500	15,500		
Maintenance and security IT service	-	62,400	62,000	Per year = 5,200 L.E per month	

Economical appraisal of the system:

This section provides the total cost of the Digital Adoption plan. Table 4 provides a comprehensive cost calculation regarding Personnel, their adequate training, hardware, software, and application purchases with their sources. Since the requirements and resources are identified table 3, the total cost of the digital adoption plan will be calculated in order to identify whether the return of investment ROI is worth value and benefit to the organization or not.

Return of Investment ROI

ROI is a measure of performance to assess the productivity or profitability of an investment. ROI Compares the investing costs to the amount of return on a particular investment. A commonly used ROI equation calculating the first year's investment is the Autodesk ROI (Autodesk, 2007).

$$\frac{\left[B-\left(\frac{B}{1+E}\right)\right]*[12-C]}{[\mathrm{A}+(\mathrm{B}\times\mathrm{C}\times\mathrm{D})]}$$

Where:
A= The cost of software + hardware + equipment (Egyptian Pounds).
B= Labor + training cost per month.
C= Training time in month.
D= Per cent of Productivity lost during training.
E= Per cent of Productivity gained after training.

The ROI of the whole adoption plan as shown in table 4:

A= (138,000+70,000+23,500+15,750) + (42,000+72,000+64,000+60,000) + (12,350+25,600+12,800) + (15,500+22,000) = 573,500 LE
B= (30,000+15,000+12,000+12,000+10,000+54,000+15,000+27,000+5,200) + (7000+5,500/1.5+3,500/3.5+3,500/2+4,000/2+1,500/0.25+1,600) ≈ 191,200
C= 14 weeks = 3.5 month
D= 75% per cent (4 h training, 2 h for practice of 8 h working days)
E= According to Autodesk's (2007) recent online survey, over half the respondents experienced productivity gains of over 50% using the Revit building information modeling solution, 33% experienced gain between 50% to 100% with average 75%, while 17% experienced productivity gains of over 100%. ((50%*50%) + (33%*75%) + (17%*100%)) = Overall minimum average gaining experience according to the survey is 67% approximately.

$$\text{First year ROI} = \frac{\left[191{,}200-\left(\frac{191{,}200}{1+0.67}\right)\right]*[12-3.5]}{[573{,}500\ +(191{,}200\times 3.5\times 0.75)]} = 0.6063 \approx 61\%$$

Considering the type of projects company x works on, as stated in section 3, if company x progressed through the implementation procedure, the ROI according to Autodesk (2007) will indicate that the profit will decrease by approximately 39% during the first year of implementation due to technological financial investment. Autodesk ROI (2007) implies that more that 60% ROI is a

healthy investment and an easy financial decision for most chief financial officers (CFOs), the next few months after full implementation will increase productivity and profit until reaching plateau, whereas after the plateau phase there will be a significant increase in revenues gradually after each financial year as shown in figure 8. For company x to go through the implementation procedure the firm must at least secure the cost of human resource, software, hardware and at least 39% extra annual profit revenue in its capital. If all these constrains are met company x should approach with the change management plan that will fully enable the transitional implementation.

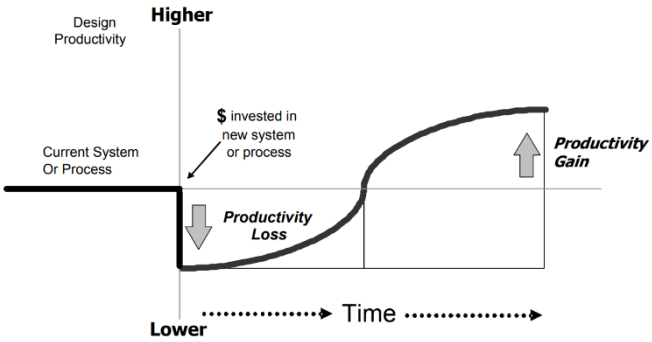

Figure 8: Design investment and productivity curve. The dark bold line shows changes in productivity after the purchase of a new system. "Training time" is the time it takes a user to become as productive on the new system as on the old, shown here where the curve crosses the horizontal axis (Autodesk, 2007).

Change management plan

According to the questionnaire, Most Egyptian practitioners do not follow BIM Standards, Methods and Protocol. They Lack an appropriate change management that suite their organization. Respondents consider these 5 strategies among the 12 as the most appropriate strategies for a wider change management plan: Enlightening top stakeholders by the benefits of BIM in project success, By providing training to professionals, By Following CIC BIM protocol, By Following BS ISO 19650, Propose organizational policies. A change management plan will be held on 2 levels: Organizational and project.

Organizational Level

According to Maali et al. (2020), seven Organizational Change Management OCM success factors for technology adoption in AECO firms are necessary for a smooth transition.

Communicating the Benefits of Change: Ayinal and Adamu (2018) stated that employees that lacked an understanding of the benefits of implementing digital divide in BIM will likely resist the change. Concluding that Company X must put this study in consideration during the training and awareness sessions. Each position in the organization should acknowledge the purpose of the training from his/her role in the organization.

Senior leadership commitment: The commitment of senior leaders in Company X is a crucial aspect, where they should be justified about the purpose and appropriateness of the proposed changes. The awareness sessions are proposed to increase the level of commitment for all upper-

level stakeholders to mitigate resistance and risk change management failure. A lack of senior change support in the AECO industry forms a vital obstacle. (Zhao et al, 2015).

Training resources: Training invested by AECO firms aids in achieving the full potential of Digital technology and BIM (Chang et al, 2017). Company X must not focus only on technical practices but also provide a change-related awareness session. Change-related training has proven to be a key factor for a successful BIM implementation (Ahn et al. 2016, Ozorhon and Karahan 2017). Company X should not hire new personnel thus training current ones and shifting their current role to a BIM related position.

Establishment of a realistic timeframe for change adoption: The Implementation plan must be long-termed and gradual (Hong et al., 2019). Company X must gradually plan long-term implementation in phases and milestones, including a checklist of detailed requirements needed in each milestone. Each of these phases should have a main objective with an adequate timeline of its start and end dates. The objective of the phases must be aligned with the BS EN ISO-19650-1,2 standards (ISO, 2018) and CIC BIM protocol (CIC, 2018) as shown in Table 5.

Change agent effectiveness: An internal team known as change agents are individuals that constantly guide and support the transition. In the BIM adoption case, they are known as BIM champions. The BIM champion member in the case of Company X is the Implementation BIM manager and his team stated in table 3. A study by Lee and yu (2015) and Ahn et al (2016) states that BIM adoption acceptance has increased in Korean AECO industries than United States ones due to the high hiring rate of change agents in Korean firms.

Table 5. Change Adoption timeframe

Phases	Start	End	Objective	Procedures
1	2nd of March 2021	2nd of May 2021	From stage1 to stage 2 standard and technological layer development	• Training Team a. • Implementing CDE • Etc • Follow iso-19650 clause 12.3 and 13.4 • Etc.
2	•	•	•	•
3	•	•	•	•
etc	•	•	•	•

Establish clear and measured benchmarks of change progress: Actual performance must be measured against the Digital adoption plan established by Company X, where celebration and reward systems should be applied upon accomplishments (Hong et al. 2019).

Workload adjustments to support the adoption: Personnel involved in the change will be added change-related meetings, tasks, and training to their workload. If Employees experienced unfavorable workloads, they would become resistant to the adoption. In time and cost focus industries like AECO, Employees become frustrated about the limited time and how to resolve

implementation arising issues (Maali et al., 2020). Company X in that case should put into consideration all these aspects during the implementation procedures.

Project Level

A study made by Darwish et al., (2020) on the Success Factors for BIM projects in AECO firms. Resulting in 15 factors. Respondents where from the Middle East mainly Egypt. Company X must change its procedures to make sure that all of these factors are successfully implemented during the delivery of its projects. The factors will be aligned with the RIBA PoW project life-cycle stages as shown in table 6, where change management procedures company x must perform are stated in each stage.

Table 6: Change Management procedures that should be followed during the project life cycle

Stages	Factors	Project Change Management Procedures
0.Strategic Definition	11	•Client Requirements must be established during the preparation stage. •Terms and agreements should be set specially the ownership of the model. • After increasing awareness levels company x can procced to work on BIM projects. •Qualified staff should be positioned to an appropriate role after training. •Competencies and experiences between employees should be present during the project. •Follow the BIM adoption strategies set in **Chapter 5 clause 2 (5.2)** •Form a **BIM Execution plan BEP**.
1.Preparation and Briefing	3,7 ,9,14	
2. Concept Design	1,2,4,5,10,12,13.15	•Coordination between stakeholders by illustrating spatial federation strategy using CDE, **ISO 19650-1:2018 section 12 (ISO, 2018)**. •All BIM features and functions shall be used during the projects. •The BIM manager and project manager shall make sure that there is a decent collaboration between all stakeholders according to the **CIC BIM protocol 2018 (CIC, 2018).** •All BIM programs must work on IFC open source. •Availability of appropriate hardware and software as shown in **table 4**. •All information should be shared with in the industries including organization, asset, project and exchange information and their requirements (OIR, AIR, EIR, EIR, AIM, PIM) as to **ISO 19650-1,2:2018** regulations. •Appropriate Planning of project scope including size.
3.Spatial Coordination	1,5	
4. Technical Design	1,5,8	
5.Manufacturing and construction	1,2,5	•Coordination between stakeholders during construction by using CDE and regulations in **ISO 19650-1,2:2018**. •Training on field practitioners on the AI-technologies and CDE stated in table 4.
6. Handover	1,6	•Coordination between stakeholders when handing over the project following a checklist of contracts, agreements terms and conditions approved by all parties in the preparation phase. •State to the appointing party all the perceived benefits of the applied Digital technologies and BIM during the project. •Gather Lessons Learned for future improvements.
7. Use		

Conclusions

The proposed model identifies a need for implementing digitalization, especially in the building industry of developing countries. This study showcases the procedures for BIM implementation by means of the proposed policies and regulations. These factors can help overcome existing constraints in the Egyptian building sector to successfully adopt BIM. The gap between digitalization and theory will be reduced as a result of this research. No research has been carried out to the best of knowledge in the Egyptian construction sector to assess the drivers of BIM deployment by determining its impact on digital technological awareness at various construction phases.

This study was conducted to propose a digital adoption plan for a main contractor firm located in Egypt. The research objective was attained through literature review and quantitative data gathering from Egyptian practitioners. The collected data was then analyzed through Strategic planning tool

SWOT, where barriers and recommendations were dissected from expert's point of view. Strategic solutions were proposed forming the main skeleton of the digital adoption plan. The solutions were followed by financial appraisal calculating the cost of the whole Digital technology solution and identifying the ROI resulting in approx. 61% returned investment in the first year. The first year's ROI was within the acceptable range so therefore a change management plan was proposed identifying recommendations and procedures the main contractor must follow in order to achieve an innovative transition.

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