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SLOW ADOPTION OF BUILDING INFORMATION MODELING: COMPARING VIEWPOINTS OF DESIGNERS AND CONTRACTORS

Ahmed Khalafallah[1], Noor Muntasir[2], Michael Gerges[3], Talib E. Butt[4], Georgios kapogiannis[5]
avk6434@psu.edu, noormuntasir@hotmail.com, michael.gerges@wlv.ac.uk, t.e.butt@northumbria.ac.uk
Beavers Myers Professor in Civil Construction Engineering and Management, Department of Civil and Environmental Engineering, Pennsylvania State University, 212 Sackett Bldg., University Park, PA 16802[1],
Graduate Student, Department of Civil Engineering, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait[2]
Associate Dean, Faculty of Science and Engineering, University of Wolverhampton, United Kingdom[3],
Senior Lecturer, Faculty of Engineering & Environment, Northumbria University, Wynne-Jones Building, Newcastle upon Tyne NE1 8ST, England, UK[4],
Associate Professor, School of Leadership and Business, Oryx Universal College in partnership with Liverpool John Moores University, Doha, Qatar[5]

Abstract:
The slow adoption of Building Information Modeling (BIM) technology poses significant problems for the construction industry in the Middle East. The root causes of this issue are purported to include a lack of understanding of its benefits and the existence of barriers to its adoption. This study investigates the slow adoption of BIM technology in the Middle East to identify solutions to facilitate BIM adoption and approaches by which stakeholders can transform to utilizing BIM. The main objectives of this research are to: (1) examine the attitudes and readiness of construction stakeholders for BIM,
(2) investigate the extent to which there is a lack of understanding of BIM benefits, (3) explore the barriers that hinder BIM adoption, and (4) identify the solutions recommended by the industry experts to promote BIM utilization. The study also compares the viewpoints of designers and contractors to identify potential differences. A questionnaire survey has been devised to gather data from stakeholder firms and experienced BIM professionals. The results revealed that the viewpoints of designers and contractors generally align, except when it comes to recognizing a few benefits such as the generation of accurate and consistent 2D drawings, achieving greater predictability in project time, enhancing communication among project stakeholders, minimizing change orders, and mitigating redesign issues. Similarly, there was a difference in recognizing a few barriers, namely, the lack of skilled personnel and the cost of training existing staff. Furthermore, the analysis led to the conclusion that the most notable advantage of BIM is improved conflict detection, and the most significant barrier is the lack of BIM training. The research culminated in offering recommendations for addressing the industry's BIM-related challenges. These suggestions encompassed raising awareness of BIM as a robust design and construction tool, supporting construction firms for adopting BIM techniques, and identifying methods to streamline the implementation process within these firms.

Keywords:
Building information modeling, construction information, construction industry, conflict detection, CAD

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BACKGROUND

Building Information Modeling (BIM) was introduced to the construction industry approximately two decades ago and continues to evolve over time (Eastman et al. 2008,Wang & Leite 2014). It is considered as a novel method to streamline the construction process, facilitate efficient design, and enhance decision-making by improving visualization and communication among project stakeholders (Babalola 2023; Eastman et al. 2008; Krygiel & Nies 2008; Wang & Leite 2014).

Construction professionals, field specialists, and researchers have been exploring the use of BIM as a pivotal information technology and tool to enhance construction efficiency and precision. Key advantages of BIM paradigm among others is to comprise: minimizing the risk of errors on construction sites, enhancing the quality and accuracy of documentation, expediting construction progress, and offering project owners a vivid visualization of their project along with cost estimates (Ahn et al. 2015).

Numerous definitions of BIM exist, but they all converge on a common concept. According to the National BIM Standard (NBIMS), BIM is described as “a digital representation of physical and functional characteristics of a facility, It also provides a shared knowledge resource for information of facility for the owner/operator to use and maintain throughout the project lifecycle” (NBIMS, 2007). This implies that the essence of BIM involves creating a virtual representation of a building before constructing it in the physical realm, allowing for the identification and resolution of issues and the simulation, analysis, and mitigation of potential impacts (Smith 2007).

BIM and its technology part extends beyond the mere creation of a 3D graphical representation of a project (Eastman et al. 2008) to also enabling monitoring of the construction process by linking 3D building elements to their corresponding schedule activities, thereby generating a 4D model that incorporates time as the fourth dimension beside the 5D model (cost) etc. as per the NBIMS report. The objective is to optimize the sequencing of project activities and provide a visual representation of the schedule (Jigsawcad Corporation 2009). Additionally, BIM can streamline the process of estimating building material quantities, especially when these quantities are directly linked to cost databases for cost estimation (Gerald et al. 2010). Hamm (2008) emphasized that BIM can also be integrated with cost data to generate a 5D simulation. This comprehensive information enhances building design by facilitating the selection of the most suitable materials for a specific project and allowing for the implementation of value engineering procedures within a fully visualized and comprehensible context (Krygiel & Nies 2008).

The transition from paper-based drafting to BIM was a long-term process. It went through enormous changes over the years. While paper drafting was the predominant method in the construction industry, in 1963, Ivan Sutherland introduced SKETCHPAD, which is considered the precursor to CAD. Initially, CAD technology was not as widely recognized as it is today (Leondes 2005), but it underwent rapid development. In 1982, ArchiCAD emerged as a significant development, being recognized as one of the initial implementations of BIM. It was the first software capable of creating 3D models while also storing data for all building elements. Subsequently, during the early 1980s, CAD software running on workstations replaced traditional drafting tables in numerous design firms (Kymmell 2008). Soon after, Object Oriented CAD structure (OOCAD) supplanted two-dimensional symbols (essentially lines) with "objects" representing building elements, complete with the ability to simulate the behavior of these elements (Batchler & Howell 2005). Given the complexity and uniqueness of construction projects, designers found it imperative to virtually construct their projects before commencing on-site work. This necessity gave rise to BIM from a technology, now a pioneering innovation that embraces a virtual design and construction approach (Damian & Yan H 2008). In the year 2000, the introduction of Revit marked a pivotal moment in the BIM world, as it employed a unified database for the entire project, signifying a revolutionary shift (Quirk 2012) and people used throughout the project management lifecycle over a Common Data Environment (CDE) could work remotely. Later BRE PAS1192 in 2013 and more recently ISO19650 (2018) were introduced so Information Management in construction to be better managed.

As per Kia (2013), BIM software can be classified into three primary groups, each tailored to specific software functions. These categories consist of: (1) BIM for modeling, (2) BIM for design analysis, and (3) BIM for 4D modeling.

It is undeniable that every client desires their project to be delivered on schedule, within the allocated budget, and with top-notch quality (Winch 2002). The efficient deployment of BIM can certainly enable this achievement. Integrating BIM technology into a project's design, construction, and operational phases should enhance work

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quality, expedite construction timelines, boost productivity and proactive behavior of Project Managers (Kapogiannis et al. 2021), and drive cost savings in the building industry (Kessinger 2008). To provide a precise overview, the advantages of BIM can be classified into four primary categories: (1) organizational benefits, (2) design-related benefits, (3) managerial benefits, and (4) construction-related benefits. Organizational benefits include BIM streamlining information access, enhancing coordination among various project disciplines, and improving conflict detection (McNell et al. 2009). Design-related benefits include enabling early-stage changes when their cost is minimal ("Productivity Benefits of BIM," n.d.), and enhancing visualization by working with a detailed 3D model of all building elements, which results in fewer design errors ("Productivity Benefits of BIM," n.d.). Managerial benefits include reducing errors, Requests for Information (RFIs), and change orders, while simplifying building lifecycle maintenance ("Productivity Benefits of BIM," n.d.). Construction-related benefits include contributing to fewer rework instances, streamlining quantity take-off processes, enhancing project planning and monitoring, and simplifying payment processing (Aranda-Mena et al. 2009; Talebi n.d.), (McNell et al., 2009; Karppinen et al. 2012; Talebi n.d.).

PROBLEM STATEMENT

Building Information Modeling (BIM) offers myriad advantages to the construction industry. However, its integration process faces multifaceted challenges that hinder its seamless adoption. Key among these impediments is:

Human Resistance: Any transformative process invariably faces resistance to change, and BIM adoption is no exception.

Knowledge Deficit: Many stakeholders lack a comprehensive understanding of BIM and its inherent benefits, creating reluctance among construction firm owners to embrace this paradigm shift.

Educational Lapses: A significant gap in the academic curriculum of engineering schools excludes BIM, leading to a dearth of executives proficient in BIM.

Economic Concerns: For construction firms, BIM adoption translates to financial outlays, whether it's for employee training, BIM specialist recruitment, or infrastructural upgrades like new hardware and software.

Despite the hurdles, it's crucial to view BIM adoption as an innovative stride, especially in an industry often perceived as fragmented. Globally, BIM adoption showcases disparities. While Western nations like the United States, United Kingdom, Germany, and France have made significant strides in BIM awareness and integration, the Middle East lags, even with its robust construction growth. Here, construction projects grapple with challenges like waste reduction, productivity enhancement, and adherence to green building norms. Tackling these intricacies necessitates collaborative procurement systems augmented by innovative tools. The Gulf Region, particularly countries like Qatar, UAE, and Saudi Arabia, has showcased significant growth. A 2017 study illuminated the burgeoning BIM use among architects and contractors: 46% employed BIM in up to 30% of their projects, while 54% surpassed this threshold. Intriguingly, in a mere two-year span, 79% of these professionals anticipate even more extensive BIM utilization. Their optimism stems from the tangible benefits they've garnered, including enhanced efficiency, minimized field conflicts, and reduced documentation errors. A resounding 80% of Middle Eastern respondents believe that their BIM ventures have yielded positive returns, with a quarter asserting an ROI upwards of 50%. However, the industry's trajectory has been stymied by dwindling staff productivity over the past half-century, compounded by project complexities and the proliferation of specialized stakeholders. While global construction cognoscenti is fervently advancing technologies like BIM, the Middle East's adoption pace remains tepid, with palpable apathy among project custodians. Though Hajj's 2021 overview shed light on some adoption barriers, comprehensive research delving into the region's BIM adoption challenges is scant. This study seeks to bridge this research void, aiming to unravel the intricacies plaguing BIM's adoption in the Middle East.

RESEARCH AIM

This study aims to assess the slow adoption of BIM in the middle east region and provide relevant recommendations. Furthermore, itunderscores the significance of implementing BIM in enhancing the design and construction processes within the Middle East's construction sector. Additionally, it delves into the barriers that impede the adoption of BIM in the Middle East, offering precise discussions aimed at providing effective solutions to overcome these challenges and streamline the implementation process. The main objectives of this research are to: (1) examine the attitudes and readiness of construction stakeholders for BIM in the region, (2) investigate the extent to which there is a lack of understanding of BIM benefits,(3)explore the barriers that hinder BIM adoption, and (4)identify the solutions recommended by the industry experts to promote BIM

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RESEARCH DESIGN

BIM technology is relatively novel in the Middle East, and consequently, there is a limited body of research addressing it (Gerges et al. 2017). This study's primary objectives are to investigate the level of awareness among construction industry stakeholders regarding BIM technology and their level of engagement with it. It also aims to emphasize the most impactful benefits of BIM. Furthermore, the research seeks to identify the challenges and barriers hindering BIM adoption in order to provide well-suited recommendations for overcoming these obstacles. This research project will be divided into 3 phases as shown in Figure 1. Phase (A) investigate the awareness of various construction industry stakeholders - including architects, engineers, and contractors - of BIM concepts and benefits. Phase (B) examines the challenges and barriers encountered during the adoption of BIM in the Middle East. Phase (C) recommends strategies and actions to overcome the barriers of implementing BIM in the Middle East.

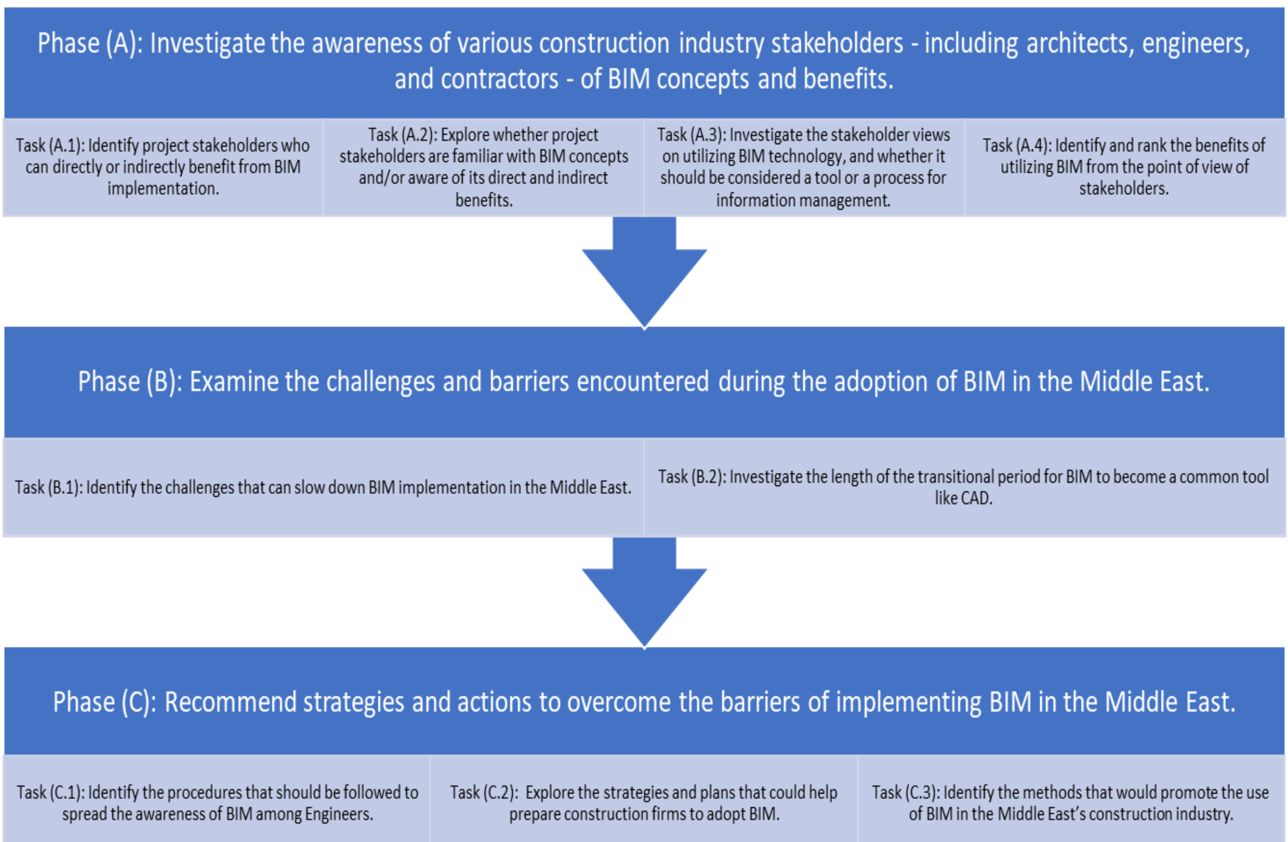

Fig. 1. Research Major Phases and Tasks

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SURVEY AND SAMPLING

To gather information and data from project stakeholders, a survey was undertaken. Questionnaires were randomly distributed to all project stakeholders, encompassing contractors, subcontractors, consultants, design firms, and construction management firms (CM), to solicit input from all parties involved in construction projects.

The questionnaire was divided into five sections: (1) Staff Attitude and Knowledge; (2) Benefits of BIM; (3) Barriers of BIM Implementation in the Middle East; (4) Recommendations; and (5) Respondent Background.

Given the relatively nascent status of the BIM market in the region, the survey focused on a relatively limited target population. Consequently, a sample of respondents was selected to best represent the entire population. Determining the appropriate sample size posed a challenge, as it is pivotal for the survey's success. An excessively large sample can result in the wastage of valuable resources like time and money, while a sample that is too small may yield unreliable results.

The chosen sample size was influenced by the desired level of precision. For this survey, a high confidence level was adopted as the foundation for selection, resulting in a relatively small sample size.

The necessary sample size was determined utilizing Eq. (1) (Mann 1995):

$$n = z^2 б^2 / E^2 \qquad (1)$$

where;

n = sample size,

z = z-value associated with the level of confidence,

б = population standard deviation, and

E = the maximum error.

The highest standard deviation was calculated using a random sample of 95 questionnaires from the first batch of collected questionnaires and it was found to be 1.132. Accordingly, in the above formula, б equals 1.132. A confidence level of 85% was selected, resulting in a corresponding z-value of 1.96, and an accepted error of 0.15 was established. Consequently, the required number of questionnaires (n) will be (1.442) * (1.1322) / (0.152) = 118.1. Hence, the minimum number of questionnaires required is 119.

RESULTS AND DISCUSSIONS

The survey was circulated among various stakeholders in the construction industry, encompassing contractors, consultants, designers, and construction management firms. A total of 95 completed surveys were gathered, and the collected data was compiled into spreadsheets, summarized, and subjected to analysis. The subsequent sections provide a more comprehensive overview of the data analysis.

Staff attitude and knowledge

Section 1 aimed to survey experts regarding their evaluation of staff attitudes and understanding of BIM concepts. Question 1 (Q.1) inquired, "Were you previously acquainted with Building Information Modeling (BIM)?"

Figure 2 illustrates that approximately 97% of the respondents were aware of BIM, signifying the credibility of the survey results. Only 3% indicated unfamiliarity with BIM. This question aimed to assess the awareness of various stakeholders about BIM, and the statistics reveal that many respondents, particularly those with less than 5 years of work experience (typically tech-savvy), are aware of BIM. However, the majority noted a lack of instruction on BIM during their undergraduate or graduate studies. This underscores the importance of incorporating BIM into engineering school curricula to better equip young engineers for their careers.

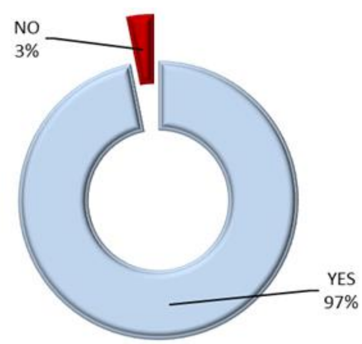

Fig. 2. Respondents Basic Knowledge about BIM

Question 2 (Q2) asked, "How would you rate your comprehension of BIM?" The aim of this question is to gauge the participants' level of familiarity with BIM technology. Figure 3 reveals that approximately 32% of the respondents possess some degree of understanding of BIM technology, while a similar percentage of 31% are highly familiar with it. Nearly equal percentages of 19% and 18% indicated that they have read or heard about BIM and

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consider themselves experts in BIM, respectively. This distribution reflects a standard familiarity pattern among the respondents in regard to BIM.

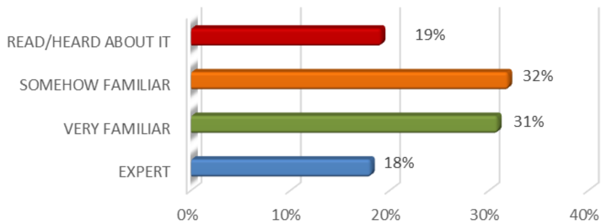

Fig. 3. Level of Familiarity with BIM

Many participants mentioned that despite being aware of BIM and recognizing its potential benefits for projects, they never felt the inclination or necessity to acquire knowledge of this new technology. They have grown accustomed to traditional working methods over the years and perceive learning a new technology as unnecessary.

Question 3 (Q3) inquired, "Have you participated in projects that employ BIM technology?" This question highlights the extent of the challenge awaiting BIM implementation in the Middle East. Figure 4 illustrates that 84% of the respondents have not been engaged in projects utilizing BIM technology, despite their awareness of the technology. In contrast, only 16% of the respondents have had such involvement. Notably, all the participants who were involved in BIM-related projects initiated their BIM experience after 2013 when large-scale projects commenced in the Middle East as part of economic development plans.

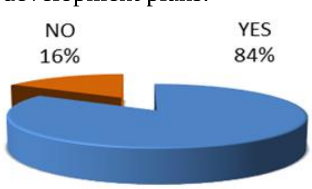

Fig. 4. Past or Current Involvement in BIM Projects

Question 4 (Q4) inquired, "Please specify the number of years of experience you have with BIM." As previously mentioned, many of the participants who began their BIM experience after 2013 did so in conjunction with the commencement of large-scale projects in the Middle East. However, engineers and modelers had prior experience with BIM outside of the Middle East. Figure 5 reveals that 85% of respondents have utilized BIM for less than 5 years. Additionally, 12% and 4% of respondents reported BIM experience ranging from 5-10 years and 10-20 years, respectively. These percentages primarily originate from respondents working with international design firms.

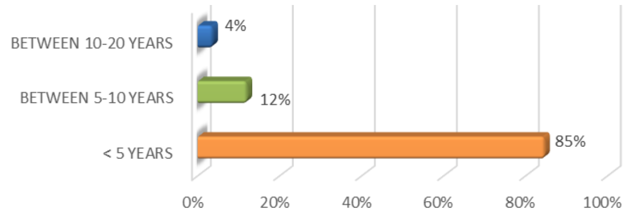

Fig. 5. Years of Experience in BIM Projects

Question 5 (Q5) asked, "Please specify the number of projects your organization has undertaken using BIM." Figure 6 indicates that approximately 84% of respondents' organizations have undertaken fewer than 5 projects using BIM, while 14% of organizations have engaged in between 5-10 BIM projects. A mere 2% of respondents' organizations have employed BIM in more than 10 projects, with this exceptional case belonging to an international design firm. Given the participants' limited experience, several risks and challenges were anticipated, as will be elaborated below.

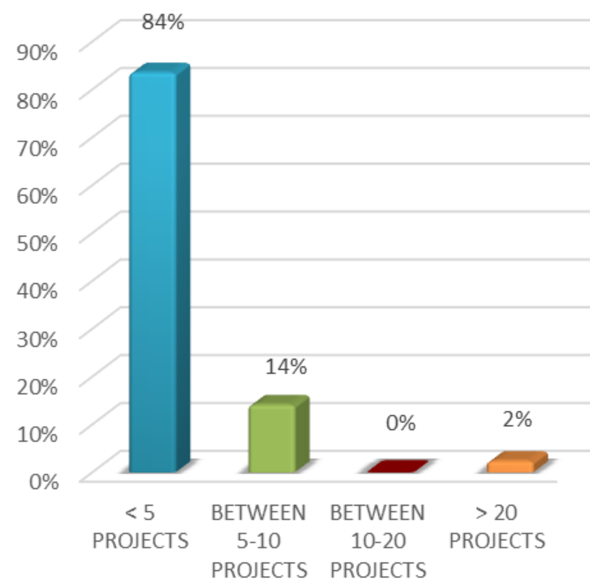

Fig. 6. Number of Projects Their Organization Undertook Using BIM

Question 6 (Q6) queried, "Are you informed about the benefits of BIM?" Figure 7 indicates that 90% of the respondents are knowledgeable about the advantages of BIM, while 10% are not. Awareness of the benefits of BIM adoption can motivate management within firms to embrace this technology and invest in staff training and development.

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However, given that many personnel in charge of firms are unaware of these benefits, numerous motivated employees end up pursuing self-guided training, incurring potentially high costs.

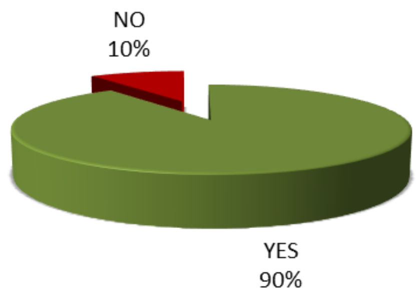

Fig. 7. Awareness of BIM Benefits

Question 7 (Q7) inquired, "Which BIM software do you employ for your projects?" Figure 8 clearly illustrates that Revit (Arch, Struct, MEP) is the most prevalent BIM software, utilized by 60% of respondents. Revit shares similarities with AutoCAD, making it relatively easy to learn for those already familiar with AutoCAD. Navisworks ranks second, with 16% of respondents using it frequently. Navisworks is commonly employed for clash detection, among other purposes, which makes it a choice for companies with minimal BIM requirements. Additionally, both Revit and Navisworks are Autodesk products, which are well-known among engineers. Approximately 8% of respondents utilize Tekla, while another 8% employ Robot. A smaller fraction, 2% of respondents, use Bentley (Arch, Struct, Mech, Elect).

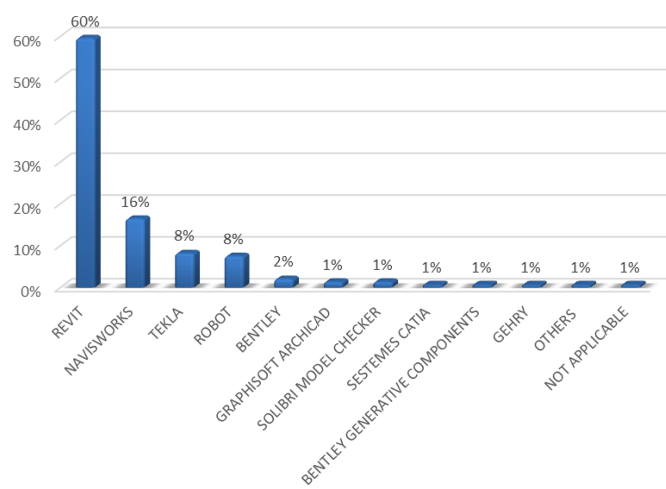

Fig. 8. BIM Software Utilized

Question 8 (Q8) posed the query, "Do you believe that implementing BIM will address construction challenges in the Middle East?" Although 69% of respondents believed that implementing BIM would resolve significant issues in the Middle East's construction sector, as shown in Figure 9, this percentage could have been higher had employees been more familiar with the benefits BIM technology offers. Furthermore, 15% thought BIM would address less substantial issues. This perspective is primarily linked to being involved in projects where BIM was implemented solely as a contractual requirement, against the preferences of contractors. About 14% of respondents were uncertain about the extent to which BIM could contribute to resolving construction challenges. Only 1% held the view that BIM would not address any construction problems in the Middle East.

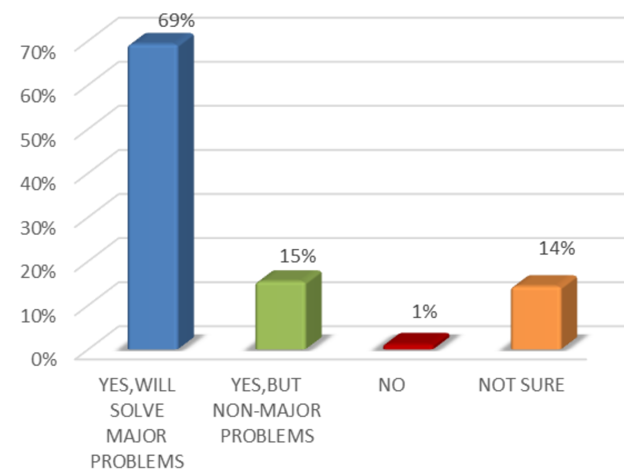

Fig. 9. BIM Contribution in Solving Construction Problems in the Middle East

Question 9 (Q9) asked, "Do you think implementing BIM will be mandated in future construction contracts in the Middle East?" Figure 10 reveals that the majority of respondents, approximately 86%, anticipate that BIM will become a mandatory requirement in future construction contracts in the Middle East. Given BIM's global prominence and rapid growth, all participants believe that the Middle East should embrace this technology and make it a contractual necessity. However, 14% of respondents were unsure about this prospect.

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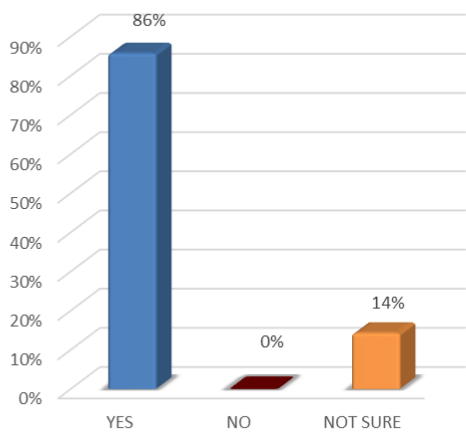

Fig. 10. Necessity of Implementation of BIM in Future in the Middle East

Question 10 (Q10) inquired, "What do you perceive BIM to be?" This question was posed due to widespread misconceptions among project stakeholders regarding the true nature of BIM. BIM extends beyond being a mere tool for producing 3D models; it encompasses a comprehensive information management process that begins during the design phase and extends through the maintenance period. Figure 11 demonstrates that although 74% of respondents viewed BIM as an information management process, they provided incorrect answers and information when asked for further details about the nature of this process. Many respondents who believed BIM was an information management process mistakenly thought it was merely a 3D representation of standard shop drawings, while others considered it a presentation tool. About 25% believed it to be a tool/software.

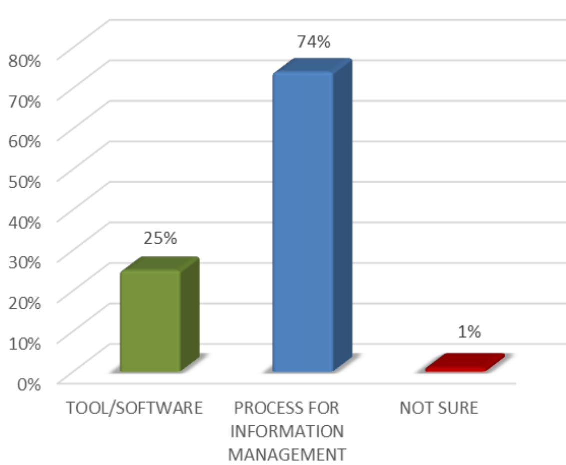

Fig. 11. Respondents Thoughts About BIM Concept

Question 11 (Q11) asked, "In your opinion, how many years will it take for BIM to become a common requirement in contracts?" The responses to this question reflect significant uncertainty regarding BIM implementation. As illustrated in Figure 12, participants' opinions were almost evenly divided between less than 5 years and 5 to 10 years.

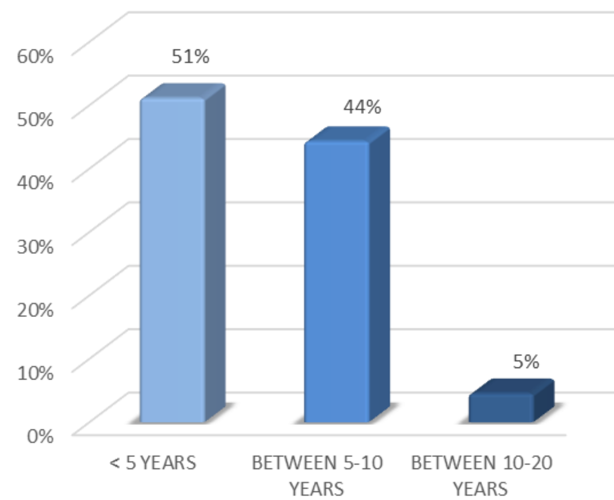

Fig. 12. Period Required Until BIM is Required in Construction Contracts

BIM Perceived Benefits

The objective of Section 2 of the survey is to pinpoint and evaluate the advantages stemming from the implementation and utilization of BIM technology. Respondents were requested to express their views on a predefined list of benefits, which were initially derived from the literature. They were asked to gauge the extent to which they agree with each identified benefit, using a 5-point Likert scale (ranging from strongly agree to strongly disagree). Emphasizing the most prominent benefits is intended to inspire engineers to embrace BIM in their projects.

The analysis of BIM benefits and barriers encompassed three distinct levels of examination. Firstly, a descriptive statistical analysis was undertaken on the Likert responses for each benefit and barrier to discern if a consensus existed among respondents. Secondly, a comparison was conducted among the anticipated benefits and barriers to identify those that most experts concurred upon. This was achieved by consolidating respondents who either agreed or strongly agreed with a particular benefit or barrier into one group and calculating the percentage of these

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respondents relative to the total number of surveyed stakeholders. Lastly, the survey explored whether differences in opinion regarding the advantages existed between two groups: contractors and designers (encompassing architects, engineers, and consultants). This analysis aimed to illuminate the most prominent benefits and barriers shared by the majority of stakeholders. The following sections discuss the aforementioned levels of analysis in more detail.

Identifying BIM individual benefits

The survey presented the participants with a list of perceived benefits of utilizing BIM. The list was compiled from the review of literature and informal interviews with BIM experts. The participants were asked to present their perception of the identified benefits on a five-point Likert scale. The three most noteworthy benefits that garnered significant interest among the participants were the ‘improved conflict detection’, ‘easier quantity take-off’, and ‘better visualization’. The following paragraphs discuss the respondents’ opinions on each perceived benefit in more detail.

Participants were asked to assess the perceived benefit of 'Improved Conflict Detection' in relation to BIM. As depicted in Figure 13, approximately 52% of respondents strongly agreed that it is indeed a significant benefit of BIM, while around 40% simply agreed with this perspective. About 7% of respondents remained neutral in their opinion, with no respondents expressing disagreement or strong disagreement. These results suggest that improved conflict detection is a substantial advantage offered by BIM.

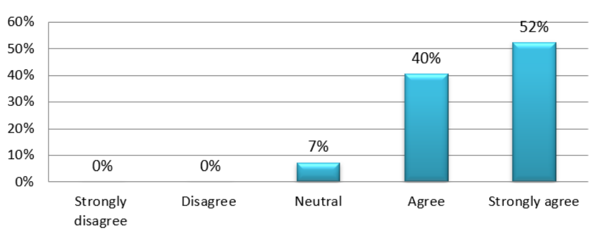

Fig. 13. Respondents' Opinions Breakdown on "Improved Conflict Detection" as a Perceived BIM Benefit

When participants were asked to evaluate 'Easier Quantity Take-off' as a perceived benefit of BIM, the majority of respondents (49%) strongly agreed that it is a notable benefit of BIM, while approximately 40% expressed agreement with this viewpoint, as illustrated in Figure 14. About 9% of respondents were neutral, and only 2% disagreed that it constitutes a benefit of BIM. No respondents strongly disagreed. Therefore, it can be concluded that BIM indeed simplifies the quantity take-off process.

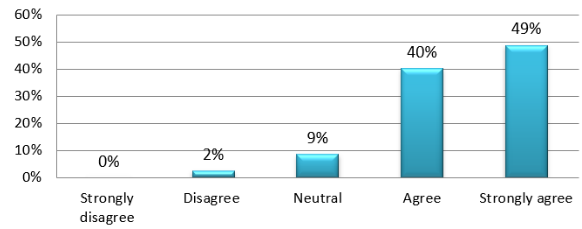

Fig. 14. Respondents’ Opinions Breakdown on "Easier Quantity Take-off" as a Perceived BIM Benefit

Participants were asked to assess 'Better Visualization' as a perceived benefit of BIM. As shown in Figure 15, a significant majority of respondents (56%) strongly agreed that it is a prominent benefit of BIM, and approximately 33% simply agreed with this assertion. Around 8% remained neutral in their opinion, and 2% disagreed with the idea that it is a BIM benefit. No respondents strongly disagreed. Hence, the participants considered that BIM does enhance visualization.

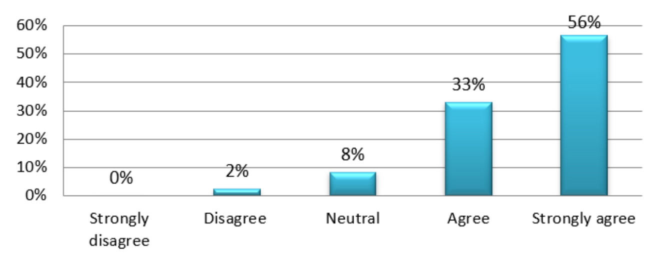

Fig. 15. Respondents' Opinions Breakdown on "Better Visualization" as a Perceived BIM Benefit

The three most noteworthy benefits that garnered the least significant interest among the participants as perceived BIM benefits were improved document management, improved productivity, and reduction in design costs.

When participants were tasked with evaluating 'Improved Document Management' as a perceived benefit of BIM, they considered it the third least benefit. Only roughly 32% of respondents strongly agreed that it qualifies as a benefit of BIM, while an additional 32% expressed agreement with this notion, as demonstrated in Figure 16. Conversely, around 29% of respondents remained neutral in their opinion, and 7% disagreed that it constitutes a benefit of BIM. No respondents strongly disagreed. Consequently, it is deduced that there is no unanimous consensus regarding

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BIM's capacity to enhance document management, leading to the conclusion that improved document management may not be a significant benefit of BIM.

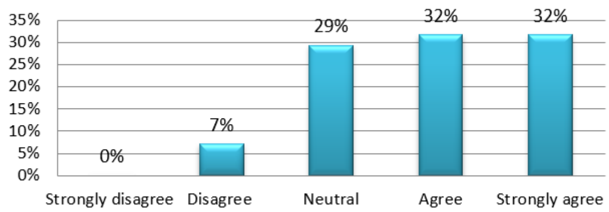

Fig. 16. Respondents' Opinions Breakdown on "Improved Document Management" as a Perceived BIM Benefit

Participants also perceived 'Improved Productivity' as the second least benefit of BIM. As shown in Figure 17, only approximately 29% of respondents strongly agreed that it is indeed a benefit of BIM, while about 34% simply agreed with this viewpoint. Approximately 34% remained neutral in their opinion, with 3% expressing disagreement. No respondents strongly disagreed. Hence, it is ascertained that there is no strong consensus that BIM unequivocally enhances productivity, suggesting that improved productivity may not be a significant benefit of BIM.

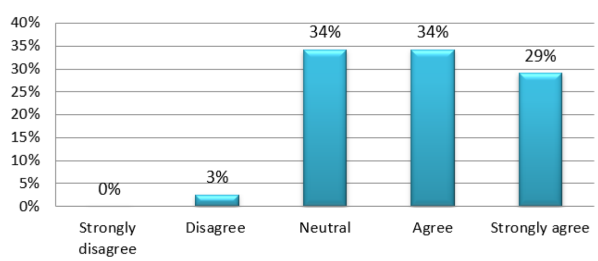

Fig. 17. Respondents' Opinions Breakdown on "Improved Productivity" as a Perceived BIM Benefit

In addition, participants also assessed 'Reduced Design Cost' as the least perceived benefit of BIM. As indicated in Figure 18, only roughly 27% of respondents strongly agreed that it qualifies as a benefit of BIM, and an additional 31% expressed agreement with this perspective. Around 25% remained neutral in their opinion, while 14% disagreed with it being a benefit of BIM. Notably, about 4% strongly disagreed. Consequently, it is deduced that this benefit garnered the least agreement among participants in terms of its significance as a perceived BIM benefit.

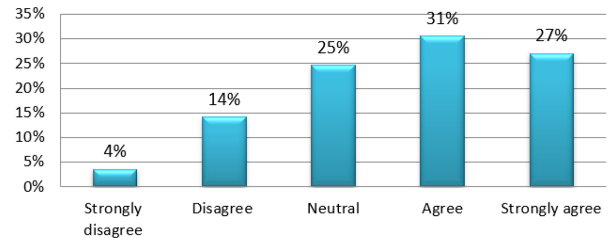

Fig. 18. Respondents' Opinions Breakdown on “Reduced Design Cost” as a Perceived BIM Benefit

Ranking of perceived BIM benefits by respondents

Figure 19 ranks the perceived benefits of BIM by the total percentage of respondents who either agree or strongly agree that the benefit is recognized. As illustrated in the figure, ‘Improved conflict detection’ tops the list with 93% of the respondents in agreement or strong agreement that it is a recognized benefit. Traditionally, detecting conflicts is accomplished by superimposing drawings of various disciplines (e.g. electrical, mechanical, and architectural) on one another and visually identifying possible clashes. BIM efficiently simplifies this procedure, as clash detection can be done by a mouse click and hence it saves effort, time, and cost.

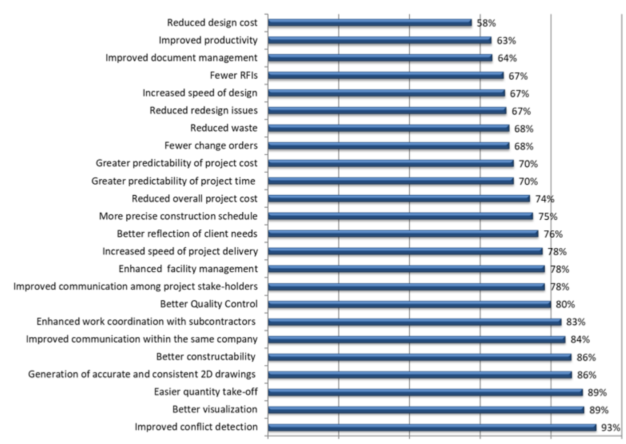

Fig. 19. Ranking of BIM Benefits

Both 'Better visualization' and 'Easier quantity take-off' jointly occupied the second position on the ranking list, each garnering an 89% agreement rate. Through BIM utilization, each building element is identified separately with all its characteristics, as well as its materials, and as such, the process of quantity take-off is simplified. In addition, creating a 3D model enhances the visualization and understanding of the project objectives and sequence. The results also demonstrate that 86% of the respondents agree or strongly agree that ‘BIM improves

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constructability.' In addition, around 84% of the respondents agree or strongly agree that 'Improved communication among specialties of the same company' is another benefit of utilizing BIM.

It is also clear from the results that a significant percentage of the respondents do not agree that utilizing BIM would result in improving productivity; as only 63% of the respondents recognize that as a benefit of utilizing BIM.

Comparing viewpoints of contractors and designers on BIM benefits

The survey respondents were categorized into two distinct groups: contractors and designers (encompassed architects, engineers, and consultants). A comparative analysis of the viewpoints of these two groups was undertaken to identify any disparities. To achieve this, the Likert scale responses were converted into a numerical scale, with 'Strongly agree' assigned 5 points, 'Agree' assigned 4 points, 'Neutral' assigned 3 points, 'Disagree' assigned 2 points, and 'Strongly disagree' assigned 1 point. The primary objective of this analysis was to elucidate the perspectives of each group. The calculations were executed in four distinct steps. Initially, it was posited that the means of responses from both contractors and designers were equivalent and consequently the calculations were conducted. The decision criterion assumed is $\alpha=0.05$. Secondly, the process involved determining the number of observations and calculating both the mean and the sum of squares for each group. In addition, the pooled variance estimate S^2_{pooled} was calculated, as well as $S_{(\bar{X}_1-\bar{X}_2)}$. Consequently, the statistical t ratio and the degree of freedom (df) were computed. Thirdly, the identification of the acceptable/ rejection range followed through obtaining the critical $t_{0.05}$ using the standard tables. To extract this data from the aforementioned tables, three parameters are utilized: (1) the hypothesized mean difference, which is zero, (2) α, which is 0.05, and (3) the degree of freedom (df). Finally, the $t_{0.05}$ value obtained from tables determines one positive and one negative values. These two values define the region of accepted possibilities. If the calculated t ratio falls in that region, no statistically significant difference will be observed in the means of the two samples. Otherwise, the equality of the means is rejected. Table 1 illustrates these computations for the benefit 'Easier Quantity Take-off.'

Table 1: Mean Comparison for Contractor and Designer Groups in Regard to "Easier Quantity Take-

	Contractors	*Designers*
Mean	4.477	4.211
Variance	0.581	0.495
Observations	44	38
Pooled Variance	0.541	
Hypothesized Mean Difference	0	
Df	80	
t Stat	1.637	
P(T<=t) two-tail	0.105	
t Critical two-tail	1.99	

It is evident from the table that the viewpoints of contractors and designers align, as the calculated statistical t-ratio (1.637) falls below the critical $t_{0.05}$ (1.99), placing the statistical t-ratio within the retention region. Consequently, no significant difference exists between the means of the two groups. Therefore, it can be inferred that both contractors and designers' opinions fall within the range between 'agree' and 'strongly agree' regarding the benefit of easier quantity take-off in the context of BIM.

Table 2 illustrates the computations for the benefit 'Generation of Accurate & Consistent 2D Drawings.' The table clearly indicates a divergence in opinions between contractors and designers, as evidenced by the obtained statistical t-ratio (3.445), which exceeds $t_{0.05}$ (1.992), placing the statistical t-ratio within the rejection region. Consequently, a significant difference exists between the means of the two groups. In conclusion, it can be deduced that contractors' opinions range between 'agree' and 'strongly agree,' whereas designers' opinions span the spectrum from 'neutral' to 'agree' regarding the benefit of generating accurate and consistent 2D drawings through BIM.

Table 2: Mean Comparison for Contractor and Designer Groups in Regard to "Generation of Accurate & Consistent 2D Drawings"

	Contractors	*Designers*
Mean	4.326	3.75
Variance	0.536	0.516
Observations	46	32
Pooled Variance	0.528	
Hypothesized Mean Difference	0	
Df	76	
t Stat	3.445	
P(T<=t) two-tail	0.001	
t Critical two-tail	1.992	

The questionnaire analysis revealed a consensus in the opinions of both contractors and designers across the majority of the listed benefits. However, notable

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discrepancies emerged in the following aspects: the generation of accurate and consistent 2D drawings, achieving greater predictability of project time, enhancing communication among project stakeholders, minimizing change orders, and mitigating redesign issues. In these specific areas, contractors and designers held differing viewpoints, indicating a lack of alignment in their perceptions of the benefits associated with Building Information Modeling (BIM).

BIM Implementation Barriers

This section aimed to investigate the barriers facing BIM implementation in the Middle East, resulting in slow adoption. It is important to highlight the most common barriers to find suitable solutions to overcome these challenges. The analysis for the third section (Barriers of BIM) followed the same procedures as the "Benefits" section.

Identifying BIM implementation barriers

The survey presented the participants with a list of perceived BIM implementation barriers. The list was compiled from the review of literature and informal interviews with BIM experts. The participants were asked to present their perception of the identified barriers on a five-point Likert scale. The three most noteworthy barriers that garnered significant interest among the participants were the lack of Bim training, lack of skilled personnel, and the conceptual misunderstanding of BIM. The following paragraphs discuss the respondents' opinions on each perceived barrier in more detail.

Participants were tasked with assessing "Lack of BIM Training" as a perceived barrier to BIM. Approximately 42% of the respondents strongly agreed that it represents a significant BIM barrier, while an additional 48% simply agreed with this viewpoint. Only 8% of the respondents remained neutral in their opinion, and a mere 2% disagreed with the notion that it constitutes a BIM barrier. No respondents strongly disagreed with this barrier. Consequently, it can be deduced that the absence of adequate BIM training is indeed a substantial impediment to BIM implementation.

Participants were tasked with assessing "Lack of Skilled Personnel" as a perceived barrier to BIM. Approximately 47% of the respondents strongly agreed that it represents a significant BIM barrier, while an additional 38% simply agreed with this viewpoint. Only 14% of the respondents remained neutral in their opinion, and a mere 1% disagreed with the notion that it constitutes a BIM barrier. No respondents strongly disagreed with this barrier. Consequently, it can be deduced that the scarcity of skilled personnel is indeed a substantial impediment to BIM implementation.

Participants were asked to assess "The Concept of BIM is not Well Understood" as a perceived barrier to BIM. Approximately 31% of the respondents strongly agreed that it represents a significant BIM barrier, while an additional 51% simply agreed with this viewpoint. Only 13% of the respondents remained neutral in their opinion, and a mere 2% disagreed with the notion that it constitutes a BIM barrier. A mere 2% of the respondents disagreed strongly with this barrier. Consequently, it can be deduced that the lack of understanding regarding the concept of BIM is indeed a substantial impediment to BIM implementation.

The three least noteworthy barriers, as perceived BIM barriers among the participants, were the refusal to learn new software, the time required to produce BIM models, and the time required to set up BIM technology.

Survey participants were asked to assess "People Refusal to Learn New Software" as a perceived barrier of BIM. Approximately 26% of the respondents strongly agreed that it is a perceived BIM barrier. Additionally, about 26% of the respondents simply agreed that it is a barrier. Roughly 29% of the respondents were neutral in their opinion, and 19% disagreed that it is a barrier of BIM. Only 1% of the respondents strongly disagreed with this barrier. Hence, it is concluded that the refusal of people to learn new software is not considered among the top significant challenges to BIM implementation, as there is no consensus among the participants regarding that.

Survey participants were asked to evaluate the "Cost of Hardware and Networks" as a perceived barrier to BIM. Approximately 20% of the respondents strongly agreed that it is a perceived BIM barrier. Additionally, about 30% of the respondents simply agreed that it is a barrier. Roughly 28% of the respondents were neutral in their opinion, and 20% disagreed that it is a barrier of BIM. Only 2% of the respondents strongly disagreed with this barrier. It is recognized that the opinions of the respondents are almost equally divided among the five answer choices. Hence, it is concluded that the cost of hardware and networks is not considered among the most significant challenges in BIM implementation, as there is no consensus among the participants regarding it being that.

Survey participants were asked to evaluate the "Cost of Hardware and Networks" as a perceived barrier to BIM.

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Around 12% of the respondents strongly agreed that it is a perceived BIM barrier. Additionally, about 38% of the respondents simply agreed that it is a barrier. Approximately 33% of the respondents were neutral in their opinion, and 20% disagreed that it is a barrier of BIM. About 15% of the respondents strongly disagreed with this barrier. Hence, it is concluded that the time required to set up BIM technology requirements is not considered among the most significant challenges in BIM implementation, as there is no consensus among the participants regarding it being that.

Ranking of perceived BIM barriers by respondents

The ranking of the perceived BIM barriers is presented in Figure 20, which illustrates that the most significant barrier to BIM implementation is the lack of BIM training, with 90% of the respondents in agreement. Additionally, 85% of the participants acknowledged that a shortage of skilled personnel poses a challenge to the widespread adoption of this technology. While some BIM users exist, most lack the necessary skills to employ BIM effectively. Moreover, the concept of BIM not being well understood serves as a significant hurdle, as 82% of the respondents agreed. As previously discussed, BIM is not merely a tool or software; it constitutes a comprehensive management process designed to benefit projects and enhance constructability. Various costs and time-related factors associated with BIM implementation contribute to the barriers faced by construction companies. These include the cost of employing additional staff, which received a 77% agreement rate, and the cost of training existing staff, with a 75% agreement rate. Furthermore, the time required to train existing staff garnered a 72% agreement rate. In addition to these challenges, 69% of the respondents agreed that the cost of new software and updates poses a significant hurdle, while 62% concurred on the cost of hardware and networks being an impediment. Several other barriers also received substantial agreement from respondents, including the absence of a requirement for BIM in government project contracts (55%), human resistance to change (52%), people's reluctance to learn new software (51%), the time required to produce models (50%), and the time needed to set up BIM technology requirements (50%). As shown in Figure 20, all the barriers included in the questionnaire received significant agreement from respondents, highlighting that they are significant challenges that need to be addressed to promote the adoption of BIM in construction companies. It should be noted that the results underscore the importance of familiarizing employees with the benefits of BIM, as 82% of respondents agreed that a lack of familiarity with these benefits constitutes a significant barrier.

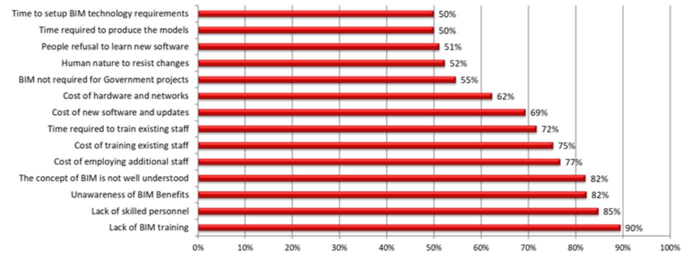

Fig. 20. Ranking of BIM Implementation Barriers

Comparing viewpoints of contractors and designers on BIM barriers

Contractors' viewpoints were compared with those of designers to identify potential differences, in a procedure similar to the one followed for the benefits. Tables 3 and 4 illustrate how the analysis was carried out.

Table 3: Mean Comparison for Contractor and Designer Groups in Regard to "The Concept of BIM is Not Well Understood"

	Contractors	*Designers*
Mean	4.065	4.053
Variance	0.818	0.699
Observations	46	38
Pooled Variance	0.765	
Hypothesized Mean Difference	0	
df	82	
t Stat	0.066	
P(T<=t) two-tail	0.948	
t Critical two-tail	1.989	

Table 4: Mean Comparison for Contractor and Designer Groups in Regard to "Lack of Skilled Personnel"

	Contractors	*Designers*
Mean	4.362	3.929
Variance	0.584	0.439
Observations	47	28
Pooled Variance	0.530	
Hypothesized Mean Difference	0	
Df	73	
t Stat	2.492	
P(T<=t) two-tail	0.015	
t Critical two-tail	1.993	

As shown in Table 3, the perspectives of both contractors and designers align, as the calculated statistical t ratio (0.066) is lower than t0.05 (1.989), placing the statistical t ratio within the retention region. Therefore, there is no significant difference between the means of the two groups. In conclusion, both contractors and designers agree that not understanding the concept of BIM is a barrier to its adoption.

The data presented in Table 4 clearly indicates that the opinions of contractors and designers diverge significantly. This is evident as the calculated statistical t ratio (2.492) exceeds t0.05 (1.993), placing the statistical t ratio in the rejection region. Consequently, there is a noteworthy difference between the means of the two groups. To sum it up, contractors' opinions tend to fall within the range of "agree" to "strongly agree," while designers' opinions generally cluster around the "agree" category regarding the barrier of lack of skilled personnel in BIM adoption.

The questionnaire revealed that contractors and designers generally share similar opinions on most of the listed barriers, except for two: the lack of skilled personnel and the cost of training existing staff.

FINDINGS

In the construction industry of the Middle East, encompassing contractors, consultants, designers, and management firms, a significant 97% are aware of Building Information Modeling (BIM). However, there exists a marked gap in formal BIM education, especially among newer professionals. While BIM's general awareness is widespread, a deep understanding is limited; only 18% consider themselves experts, and a concerning 25% view BIM merely as a 3D tool or software. This points to a broader educational shortfall, as most did not receive BIM training during their academic years. Furthermore, a reluctance to shift from traditional methods, despite BIM's recognized advantages, is evident. A majority haven't engaged in BIM projects, and those who have typically started post-2013. Looking ahead, while 86% foresee BIM as a future mandate in construction contracts, there's uncertainty about its integration timeline, with opinions divided between a swift or more gradual adoption over the next decade.

Moreover, adopting new technologies in any industry often encounters resistance, and the construction sector is no exception. Several factors contribute to this hesitancy:

1. Resistance to Change: Many professionals, accustomed to specific methods and tools over years, often resist new approaches. This resistance intensifies if they fail to perceive immediate advantages.
2. Fear of Learning Curve: The daunting prospect of mastering a new technology can deter many. The belief that substantial time and effort will be required to learn a new system can be off-putting.
3. Worries About Productivity: Transition phases, especially the early stages of familiarizing oneself with new software, can result in slowdowns. What once was simple might seem convoluted in a new system, causing apprehensions about reduced efficiency.
4. Inadequate Training: The lack of proper training and support can further heighten reluctance. Without appropriate guidance, diving into unfamiliar technological terrains can seem overwhelming.
5. Overlooking Long-Term Gains: The immediate challenges posed by a new technology are evident, but its long-term benefits might be obscured. If the enduring merits of tools like BIM—enhanced efficiency, improved teamwork, and minimized errors—are not emphasized, the motivation to navigate initial obstacles dwindles.
6. Generational Divide: Technology adaptation can also be age-dependent. Digital natives, or the younger generation, might find it easier to acclimatize to novel software than older professionals who began their careers in a less tech-centric environment.
7. Organizational Dynamics: The ethos of a company significantly influences tech integration. In the absence of a top-down emphasis on continuous learning and adaptation, employees might not feel the urgency to embrace new tools.

In essence, while the merits of technological advancements are undisputed, a confluence of individual, generational, and organizational factors can often stymie seamless adoption.

Moreover, based on the study results shown that Lessons on BIM Adoption in the Middle East:

1. **Awareness vs. Application:** It's evident that while many professionals are aware of BIM, a considerable number lack practical experience. This difference between knowing and doing poses a significant barrier.
2. **Comfort with the Status Quo:** Many in the industry find solace in sticking to known, traditional methods. This inertia can make the shift to newer technologies like BIM seem intimidating.
3. **Understanding BIM:** Misunderstandings about BIM abound. Instead of recognizing it as a comprehensive information management system, some simplify it to just a piece of software or a 3D design tool. This reductionist view can hinder its broader acceptance and utilization.

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4. **Education and Training Deficit:** The absence of BIM in mainstream academic curricula and professional training programs is a glaring oversight. Without proper education, the bridge between BIM's potential and its actual implementation remains uncrossed.

5. **Perception of BIM:** While many acknowledge the depth of BIM as an information management process, there are misconceptions about it being just software or a 3D modeling tool. This limited perspective could hinder the realization of BIM's full potential in projects.

6. **Resistance to New Software:** While the "Refusal to Learn New Software" barrier wasn't the most significant, it still plays a role. Professionals accustomed to traditional methods might view the transition to BIM as daunting, especially if they anticipate a steep learning curve or potential productivity loss during the initial stages.

7. **Productivity & Design Cost:** Although BIM is touted to improve productivity and reduce design costs, the survey results indicate mixed feelings about these benefits. If professionals are skeptical about BIM's capacity to enhance productivity or cut costs, they might be hesitant to adopt it.

In a nutshell, while the Middle East exhibits keenness in acknowledging BIM's potential, hurdles ranging from practical inexperience, adherence to old methods, misconceived notions, and educational gaps hamper its seamless integration. Hence, the iimpact on Slow BIM Adoption in the Middle East based on the study are:

- **Skills and Knowledge Gap:** The lack of skilled personnel and comprehensive understanding of BIM suggests that educational institutions and industry training programs in the Middle East might not be adequately preparing professionals for BIM implementation. This gap is a significant impediment to adoption.

- **Misconceptions:** Misunderstandings about BIM's capabilities and scope can lead to underutilization or incorrect implementation. Clarifying what BIM can offer and dispelling myths is crucial.

- **Perceived vs. Actual Benefits: If** the perceived benefits of BIM don't align with professionals' actual experiences, there might be disillusionment or scepticism about its value.

- **Cultural and Organizational Factors:** The broader cultural context of the construction industry in the Middle East, including resistance to change and organizational inertia, might also play a role in the slow adoption.

In summary, the slow adoption of BIM in the Middle East is influenced by a combination of factors, including gaps in skills and understanding, misconceptions about BIM's capabilities, and potential misalignments between perceived and actual benefits Addressing these challenges requires concerted efforts in education, training, communication, and organizational change management.

RECOMMENDATIONS

The adoption of Building Information Modeling (BIM) in the Middle East's construction sector presents a complex landscape. The awareness among professionals is high, yet the formal education and deep understanding of BIM are lacking, which is crucial for its effective implementation. Here's a critical analysis based on the cited sources and the information provided:

BIM Adoption Rates:

The Middle East, despite being a hub for monumental construction projects, lags in BIM adoption compared to many developed regions. The lack of mandate in most Middle East regions for BIM usage except for places like Dubai, indicates a slower pace of technological adoption in the construction sector (Hajj, et, al. , 2023

Barriers to Adoption:

A significant barrier to BIM adoption in the Middle East is the lack of formal BIM education among professionals, especially the newer ones. The gap in skills and knowledge is evident from the fact that despite high awareness, only a small percentage consider themselves experts. This educational deficit extends to the academic curriculum and professional training programs, which do not adequately prepare individuals for BIM implementation (Meconstruction 2017)

Misperceptions about BIM:

Misconceptions about BIM's capabilities appear to hinder its broader acceptance and utilization. The reductionist view of BIM as merely a 3D tool or software rather than a comprehensive information management system can lead to underutilization or incorrect implementation. Clarifying what BIM can offer and dispelling myths is crucial for enhancing its adoption rates.

Resistance to Change:

The construction industry, being traditionally resistant to change, finds comfort in sticking to known methods. The daunting prospect of mastering new technology like BIM

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can deter many, especially when coupled with fears of a productivity dip during the transition phase. Organizational dynamics also play a significant role; without a top-down emphasis on continuous learning and adaptation, employees might not feel the urgency to embrace new tools (Wang, et al, 2022)

Regional Specifics:

Regional mandates, like the one by Dubai Municipality, have shown a pathway for BIM adoption, yet the overall Middle Eastern construction industry still has a long way to go in terms of fully integrating BIM into everyday practices. Country-specific studies, like the one on the Saudi Arabian construction industry, underline that despite a boom in construction, BIM adoption is yet to be fully realized45.

Future Prospects:

The anticipation of BIM becoming a future mandate in construction contracts shows a positive outlook towards embracing BIM, yet the uncertainty about its integration timeline reflects the existing hesitations and possibly the lack of a concerted strategy for its implementation.

In conclusion, the Middle East demonstrates a keen recognition of BIM's potential, but hurdles like practical inexperience, adherence to old methods, misconceptions, and educational gaps impede its seamless integration. Addressing these challenges would require concerted efforts in education, training, communication, and organizational change management to bridge the existing gaps and accelerate BIM adoption in the region.

CONCLUSIONS

This research aimed to delve into the challenges associated with implementing BIM in the Middle East construction projects. Its primary objectives encompassed assessing the awareness of project stakeholders regarding the BIM concept and its benefits, identifying the obstacles hindering BIM adoption in the Middle East, and proposing effective solutions to surmount these barriers while promoting BIM utilization within the Middle East construction sector. To achieve these goals, an extensive survey was conducted, with 95 questionnaires distributed among various project stakeholders. The questionnaire was structured into five sections, namely (1) Staff Attitude & Knowledge, (2) Benefits of BIM, (3) Barriers to BIM Implementation in the Middle East, (4) Recommendations, and (5) Respondents' Background. In-depth analyses were conducted to highlight the most prominent advantages of BIM, as well as the most significant obstacles impacting BIM implementation.

Building Information Modeling (BIM) offers transformative potential for the Middle Eastern construction industry's design and construction processes. However, its adoption has lagged, prompting this research to uncover underlying reasons. Our findings reveal that while most construction stakeholders are aware of BIM, there's a significant gap between awareness and a thorough understanding of its capabilities, especially among early-career professionals. This points to educational shortfalls. Furthermore, mixed perceptions about BIM's benefits, particularly regarding productivity and cost savings, emerge as challenges. Several barriers, from the hesitancy to learn new software to broader organizational inertia, impede BIM's widespread adoption. Therefore, to create a collaborative culture that will help improve and speed the BIM adoption to the region, a multifaceted approach is vital: integrating BIM training into academia, dispelling misconceptions through targeted campaigns, and fostering a receptive organizational culture. Engaging with industry experts can further enhance the region's BIM readiness, marking a path towards heightened efficiency and innovation in Middle Eastern construction.

REFERENCES

Augustsson, G. I. (2007) “Building Information Modeling and the impact on the building industry”. Copenhagen: Copenhagen Technical Academy [Online]. Available at: http://www.fsr.is/lisalib/getfile.aspx?itemid=4006.

Ahn, Y., Kwak, Y., and Suk, S. (2015). "Contractors’ Transformation Strategies for Adopting Building Information Modeling." J. Manage. Eng. , 10.1061/(ASCE)ME.1943-5479.0000390 , 05015005.

Aouad, G., Wu, S., Lee, A., & Onyenobi, T. (2012). Computer aided design guide for architecture, engineering, and construction. London: SPON Press.

Aranda-Mena, G., Crawford, J., Chevez, A., & Froese, T. (2009). Building information modeling demystified: does it make business sense to adopt BIM? International Journal on Managing Projects in business, 2(3), 419-434

Awad, R. (2013). SURVEYING BIM IN THE LEBANESE CONSTRUCTION INDUSTRY. Department of Civil Engineering Lebanese American University Byblos, Lebanon, Retrieved from http://www.iaarc.org/publications/fulltext/isarc2013Paper264.pdf

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Available at www.emiratesscholar.com

Autodesk (2017). Business Value of BIM in Middle East. Autodesk. Available at: https://damassets.autodesk.net/content/dam/autodesk/www/campaigns/emea/docs/business-value-of-bim-in-middle-east-smr-2017-1.pdf (Accessed: [09/10/2022])

Babalola, A., Musa, S., Akinlolu, M. T., & Haupt, T. C. (2023). A bibliometric review of advances in building information modeling (BIM) research. Journal of Engineering, Design and Technology, 21(3), 690-710.

Bentley, K. (2003). "Does the Building Industry Really Need to Start Over?" Bentley Systems, Incorporated. Retrieved from http://www.laiserin.com/features/bim/bentley_bim_whitepaper.pdf

Calvert, N. (n.d.). Why WE care about BIM…. Retrieved from http://www.directionsmag.com/entry/why-we-care-about-bim/368436

Dean B. Thomson, Ryan G. Miner. (2006). Building Information Modeling - BIM: Contractual Risks are changing with Technology. Available: http://www.aepronet.org/ge/no35.html.

Deke Smith, AIA. (2007). An Introduction to Building Information Modeling (BIM). Journal of Building Information Modeling. 1 (1), p12-14.

Dossick, C. S., and Neff, G. (2010). "Organizational divisions in BIM enabled commercial construction." J. Constr. Eng. Manage., 10.1061/ (ASCE)CO.1943-7862.0000109, 459–467.

Dzambazova T., Krygiel E., Demchak G. (2009).Introducing Revit Architecture 2010: BIM for Beginners. New York: Wiley Publishing. P2-38.

Eastman, C. M., Teicholz, P., Sacks, R., and Liston, K. (2008). BIM handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers, and Contractors, Wiley, Hoboken, NJ, USA.

El Hajj, C., Martínez Montes, G. and Jawad, D. (2023), "An overview of BIM adoption barriers in the Middle East and North Africa developing countries", Engineering, Construction and Architectural Management, Vol. 30 No. 2, pp. 889-913. https://doi.org/10.1108/ECAM-05-2021-0432

Fischer, M., & Kunz, J. (2004). The Scope and Role of Information Technology in Construction. California: Stanford University

Flynn, L. (2006) Getting on Board with Building Information Modeling using 3-D modeling to integrate the design and construction process, McGraw Hill, available: http://continuingeducation.construction.com/article.php?L=45&C=310&P=7.

Forbes, L., & Ahmed, S. (2010). Modern construction: Lean project delivery and integrated practices. Boca Raton, FL: CRC Press.

Gallaher MP , O'Connor AC , Dettbarn JL , Gilday L . Cost Analysis of Inadequate Interoperability in US Capital and Facilities Industry, 2004, National Institute of Standards and Technology, (NIST), Gaithersburg, MD, USA, NIST Report.

Gerges, M., Austin, S., Mayouf, M., Ahiakwo, O., Jaeger, M., Saad, A., & El Gohary, T. (2017). An investigation into the implementation of Building Information Modeling in the Middle East. Journal of Information Technology in Construction, 22, 1-15.

Hamm J. (2008). Transforming Construction Industry Performance through the application of revolutionary virtual design and construction technologies, and the essential role for education in this happen. Jenko Cad Education Consultancy: UK.Available: http://ctiweb.cf.ac.uk/news/events/beecon2006/pdf/P17_Jenny_Hamm.pdf.

Hardin, B. (2009). BIM and construction management: Proven tools, methods, and workflows. Indianapolis, IN: Wiley.

Howell I., Batcheler B. (2008). Building Information Modeling Two Years Later – Huge Potential, Some Success and Several Limitations. USA. Available: http://www.laiserin.com/features/bim/newforma_bim.pdf.

Hwang, B. G., Thomas, S. R., Haas, C. T., & Caldas, C. H. (2009). Measuring the impact of rework on construction cost performance. Journal of Construction Engineering and Management, 135(3), 187-198.

Jigsawcad Corporation. (2009). Building Information Modeling (BIM) and its Return on Investment. Available: http://www.jigsawcad.com/articles/october- 2008/building-information-modelling-(bim)-and-its-return-on-investment.aspx.

Kapogiannis, G., Fernando, T. and Alkhard, A.M. (2021), "Impact of proactive behaviour antecedents on construction project managers' performance", Construction Innovation, Vol. 21 No. 4, pp. 708-722. https://doi.org/10.1108/CI-02-2020-0029

Karppinen, A., Törrönen, A., Lennox, M., Peltomäki, M., Lehto, M., Maalahti, J., et al. (2012). Common BIM Requirements 2012: Series 13: Use of models in

Emirati Journal of Civil Engineering and Applications
Vol 1 Issue 1 (2023)
Pages (70- 88)

Available at www.emiratesscholar.com

construction. Retrieved from Building Smart Finland: http://www.en.buildingsmart.kotisivukone.com/3

Kessinger, K. (2008). Recognizing the benefits of Building Information Modeling. Available:http://www.constructionsoftwarereview.com/blog/2008/09/05/recognizing-thebenefits-of-building-information-modeling.

Khemlani, L. (2006). Use of BIM by facility owners: an 'expositions' meeting. DESIGNERSbytes Building the Future.

Kia, S. (2013). Review of Building Information Modeling (BIM) Software Packages Based on Assets Management. In Introduction to Building Information Modeling (BIM) (pp. 101-139). Amirkabir University of Technology.

Krygiel E., Nies B. (2008). Green BIM: Successful Sustainable Design with Building Information Modeling. New York: Wiley Publishing. P25-51.

Kymmell W. (2008). Building Information Modeling: Planning and construction managing construction projects with 4D CAD and Simulation. USA: McGraw- Hill Companies. P1-87.

Lane, T. (2011). BIM: The inside story. Retrieved from http://www.building.co.uk/bim-the-inside-story/5021676.article

Lee, N., Dossick, C., & Foley, S. (2013). Guideline for Building Information Modeling in Construction Engineering and Management Education. J. Prof. Issues Eng. Educ. Pract. Journal of Professional Issues in Engineering Education and Practice, 266-274.

Mann, P. S., "Statistics for Business and Economics", John Wiley & Sons, Inc., 1995.

McEathron, D (2008). BIM: Building Information Modeling, What is BIM?. Davey McEathron Architecture. Retrieved from http://www.autodesk.com/bim

McGraw-Hill (2011). BIM in the Middles East 2011: The reality and the way forward (Survey Report). Retrieved from: http://www.bimjournal.com/wp-content/uploads/2011/05/Full-BIM-Report-Web.pdf

McNell et al., 2009. Building Information Modeling. Retrieved from http://www.infocomm.org/cps/rde/xbcr/infocomm/Brochure_BIM.pdf

Meconstructionnews (2017) Technology adoption and innovation in the Middle East building construction industry. ME Construction News. Available at: https://meconstructionnews.com/25444/technology-adoption-and-innovation-in-the-middle-east-building-construction-industry

Navendren, D., Manu, P., Wildin, K., Shelbourn, M., & Mahamadu, A. (2014). Briefing: Towards exploring profession-specific BIM challenges in the UK. Proceedings of the ICE - Management, Procurement and Law,167(4), 163-166.

Nawar, H. (2014). 10 Barriers to a full BIM deployment in the Middle East. Retrieved from https://www.linkedin.com/pulse/20140618063126-335284092-10-barriers-to-a-full-bim-deployment-in-the-middle-east

Koushki, P.A., Al-rashid, K. & Kartam, N. (2005) "Delays and cost increases in the construction of private residential projects in Kuwait." Department of Civil Engineering, Kuwait University. Retrieved from http://www.tamu.edu/faculty/choudhury/articles/22.pdf.

Pan, Y., & Zhang, L. (2023). Integrating BIM and AI for smart construction management: Current status and future directions. Archives of Computational Methods in Engineering, 30(2), 1081-1110.

Phiri, M. (1999). Information technology in construction design. London: Thomas Telford. Retrieved from https://books.google.com.kw/books?id=zn6uLnZEvAUC

Productivity Benefits of BIM. (n.d.). Retrieved from http://www.building.govt.nz/UserFiles/File/Publications/Building/Technical-reports/nz-bim-productivity-benefits.pdf

Quirk, V. (2012). A Brief History of BIM. Retrieved February 16, 2016, from http://www.archdaily.com/302490/a-brief-history-of-bim

Robert E. Chapman, (2004). Cost-Effective Responses to Terrorist Risks in Constructed Facilities. U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology. Retrieved from http://fire.nist.gov/bfrlpubs/build04/PDF/b04002.pdf

Sequeira, J. (2015). BIM use still lacking in Gulf, consultants say. Retrieved from http://meconstructionnews.com/story/4526/bim-use-still-lacking-in-gulf-consultants-say

Smith, D. (2007). "An introduction to Building Information Modeling (BIM)". Journal of Building Information Modeling, 12-14.

Talebi, S. (n.d.). EXPLORING ADVANTAGES AND CHALLENGES OF ADAPTATION AND IMPLEMENTATION OF BIM IN PROJECT LIFE CYCLE. Retrieved from

Emirati Journal of Civil Engineering and Applications
Vol 1 Issue 1 (2023)
Pages (70- 88)

Available at www.emiratesscholar.com

http://usir.salford.ac.uk/32275/3/S_Talebi_-_Exploring_Advantages_and_Challenges_of_Adaptation_and_Implementation_of_BIM_in_Project_Life_Cycle_(1).pdf

Taylor, J. E. & Bernstein, P. G. (2009) Paradigm trajectories of building information modeling practice in project networks. Journal of Management in Engineering, 25, 69.

Teicholz, P. (2013). "Labor-productivity declines in the construction industry: causes and remedies." ⟨http://www.Designersbytes.com/viewpoint/2013/ issue_67.html⟩ (Jul. 2, 2013).

Villella, P. (2009). ASHRAE Introduction to BIM, 4D and 5D. Retrieved December 6, 2015, from http://www.cadsoft-consult.com/blogs/architecture/2009/09/ashrae-introduction-to-bim-4d-and-5d/

Wang, L., & Leite, F. (2014). Process-Oriented Approach of Teaching Building Information Modeling in Construction Management. J. Prof. Issues Eng. Educ. Pract. Journal of Professional Issues in Engineering Education and Practice,140(4), 04014004.

Wang, T.; Owusu, E.K.; He, Q.; Tian, Z.; Wu, D.(2022) Empirical Assessments of the Determinants of Construction Megaprojects' Success: Evidence from China. Sustainability, 14, 14730. https://doi.org/10.3390/su142214730

What is BIM? (2013, December 9). Retrieved from http://www.tekla.com/about/what-is-bim

Whyte, J., Bouchlaghem, N., Thorpe, A., & Mccaffer, R. (1999). "A survey of CAD and virtual reality within the house building industry". Engineering Construction and Architectural Management, 6, 371-379.

Winch, G. (2002). "Managing Construction Projects: An Information Processing Approach." Oxford: Blackwell Science.

Yan, H., Damian, P. (2008). "Benefits and Barriers of Building Information Modeling." Department of Civil and Building Engineering, Loughborough University, UK

Young, N. W., Jones, S. A., Bernstein, H. M., and Gudgel, J. E. (2009). "The business value of BIM: Getting building information modeling to the bottom line." McGraw-Hill construction SmartMarket rep., New