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Building Information Modeling Capability in Mitigating Change Orders and Cost Overrun

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The Jordanian construction industry faces notable challenges, particularly about variation orders (VOs), contributing to budget overruns and project delays. The Jordan Engineers Association poll in 2020 found that variation orders (VOs) accounted for 23% of cost overruns in construction projects in Jordan. Research undertaken by the Ministry of Public Works and Housing in 2019 found an average of 948 change orders per year, representing 25.5% of the total value of the projects. Our study introduces a highly tailored evaluation method to gauge the effectiveness of Building Information Modelling (BIM) in addressing these challenges. The study assesses the efficacy of Building Information Modelling (BIM) in diminishing variation orders (VOs) by examining sophisticated BIM functionalities. The study employs an intricate case study and diverse construction project data to construct a model that assesses the capacity of BIM to reduce project modifications and enhance cost efficiency. A novel approach has been devised to enhance the optimization of building information modeling (BIM) in the construction industry of Amman, Jordan. The objective of the concept is to minimize variation orders (VOs) and enhance project management. The study employs research approaches, such as semi-structured interviews and questionnaires, to pinpoint the essential abilities contributing to change orders. After comprehensively analyzing BIM's global and Middle Eastern applications, we created the model. The findings indicate that enhancing Building Information Modelling (BIM) capabilities can effectively mitigate the occurrence of variation orders within Jordan's building sector. The approach promotes the cooperation of stakeholders, sets quantifiable benchmarks, and strategically employs BIM for preliminary risk assessment. This research substantially enhances the productivity and cost-effectiveness of construction projects in Jordan, offering vital insights for professionals and policymakers.

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INTRODUCTION

In architecture, engineering, and construction, many Building Information Modeling (BIM) capability and maturity models serve as instrumental tools for professionals to assess the efficacy of their BIM utilization. These models, designed to meet different user needs, carefully analyses different aspects of BIM deployment. However, the construction sector in Jordan faces a significant problem in the form of variation orders. Research [1] classifies the causes of variation orders into four categories: client-related, contractor-related, consultant-related, and unforeseen circumstances[1]. Consultants are responsible for 50% of the variation orders, while clients and unforeseen circumstances account for 20% each. Contractors, on the other hand, are only responsible for 10% of the variation orders[2, 3]. Despite previous efforts to address the root causes of variation orders in Jordan, they persist as a significant problem. Experts recognize Building Information Modeling (BIM) as a groundbreaking tool that can reduce errors and improve workflows in construction projects [2]. However, it only works if the project is ready for it, and in Jordan, a lack of alignment often leads to changes and more variation orders [3]. Our research delves into the extent of Building Information Modeling (BIM) utilisation among contractors in Jordan. If the user base proves substantial, the intention is to bolster BIM usage correspondingly. Conversely, in the case of a limited user base, we propose to advocate for the optimal utilisation of BIM in the Jordanian context[4]. The findings revealed a restricted number of BIM users [4]. Consequently, we expanded our research initiatives to champion the adoption of BIM in Jordan. Our overarching goal is to develop a robust evaluation model to verify the appropriateness of BIM for diverse projects. Simultaneously, we aim to conduct a case study exploring the correlation between successful BIM deployment and reducing modification orders. Additionally, we seek to offer practical recommendations for improving BIM implementation in Jordanian construction companies. Envisioning a more efficient industry, our vision is to anticipate a substantial decrease in variation orders for a prosperous future in the Jordanian construction sector [5].

The construction industry is intricate and ever-changing, with several factors that impact project schedules, quality, safety, and costs[5]. Building Information Modelling (BIM) has the potential to enhance the efficiency and effectiveness of managing building projects[6]. BIM is employed to manage two-story villas in Jeddah, resulting in time and cost savings, among other advantages. Building Information Modelling (BIM) can address and resolve these challenges. BIM enables construction project managers to simulate, visualize, and assess their projects realistically. This platform effectively combines construction data, enhancing stakeholder participation and reducing construction time and costs. BIM is advantageous throughout the first stages of building project design. Project managers can employ Building Information Modelling (BIM) to create detailed architectural models to identify issues at an early stage. Timely identification aids in preventing costly modifications and construction setbacks. BIM enables project managers to simulate and evaluate design decisions to assess their potential impact on project schedules and financial resources. Integrating construction data facilitated the design of the two-story dwellings in Jordan through BIM. Building Information Modelling (BIM) was employed to evaluate the feasibility of the design and pinpoint any issues [5]. BIM facilitated project managers in circumventing costly redesigns and delays by assessing various design options before commencing construction. BIM also monitored the project's advancement and identified potential areas for enhancement, resulting in time and cost savings [6]. BIM improved stakeholder engagement and communication. Building Information Modelling (BIM) facilitated instantaneous collaboration among all parties involved to achieve objectives. BIM facilitated collaboration among designers, architects, builders, and other stakeholders in developing the two-story residences in Jordan. Collaboration enhanced the quality of the project and minimized miscommunications [7,8]. BIM has enhanced project management through the consolidation of construction data. Project managers can monitor the advancement and implement changes by creating a digital representation of the construction project. This accelerated the construction process and reduced costs [9].

LITERATURE REVIEW

The construction industry has widely adopted Building Information Modelling (BIM) due to its ability to enhance project management and communication, reduce errors and rework, and improve project outcomes [10]. BIM is a digital model representing a building or facility's physical and functional characteristics. It can be used for design, construction, and operations. Research has demonstrated that BIM significantly reduces both time and costs for construction projects, enhancing overall quality and safety [11]. One of the main benefits of BIM is its ability to improve collaboration and communication among project stakeholders, such as architects, engineers, contractors, and owners [12]. Using a shared digital model, stakeholders can collaborate instantaneously and make decisions based on precise and up-to-date information. This reduces the likelihood of errors, conflicts, and the need for revisions, resulting in time and cost savings; multiple studies have investigated the benefits of Building Information Modelling (BIM) for construction projects [13].

This study presents a tailored BIM competency assessment model specifically created for the construction sector in Jordan, addressing the challenges associated with virtual organizations. It builds upon prior research findings [14]. The model methodically integrates crucial components, including change management, cooperation, model correctness, precision, and stakeholder involvement. This guarantees a thorough assessment of BIM's capacity to reduce variation orders (VOs) [14,15]. Through a detailed examination of the circumstances in Jordan, the model surpasses the conventional analysis of BIM. The objective is to revolutionize construction projects by prioritizing Building Information Modelling (BIM) and its capacity to minimise Variation Orders (VOs) [16]. This research has the potential to substantially impact national standards, enhance worker training, and promote the adoption of global best practices. This study improves the Jordanian construction industry by providing it with Building Information Modelling (BIM) capabilities, leading to a more efficient and satisfying future for the sector. The "onion model" symbolises the intricate and all-encompassing nature of research methodology, akin to gradually removing layers of an onion to reveal its essence, which is the gathering and examination of data. Figure 1 depicts this concept. Before selecting data gathering and analysis methods, researchers must thoroughly scrutinise and evaluate these layers, each offering unique insights into the research endeavour [17]. The research philosophy, situated at the outermost layer, comprises the researcher's fundamental beliefs regarding knowledge generation, such as positivism or interpretivism. The research strategy is supported by extra layers between the conceptual foundations and the data-centric core [18]. The chosen research methodology, influenced by the selected philosophical framework, demonstrates the overarching orientation of the investigation, such as whether it is deductive or inductive [19]. The layer encompasses methodological decisions, specific tools, and processes for gathering and examining data (e.g., surveys, interviews, statistical analysis). The fourth and fifth tiers of the research framework delineate the selected research methodology (e.g., case study, experiment) and the temporal scope (e.g., cross-sectional, longitudinal) for performing the research [20].

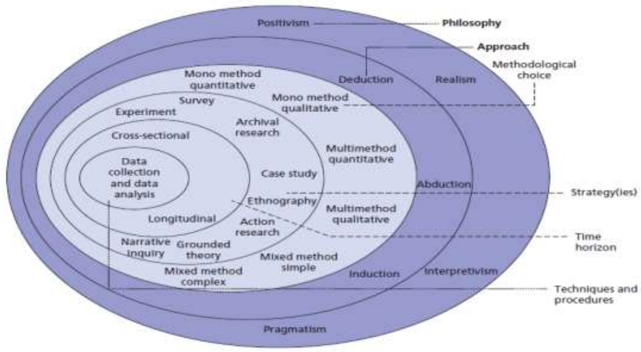

Fig. 1. Research Onion model [1]

BIM is a collaborative approach that connects people, processes, and digital models in construction projects. It facilitates smooth information flow and communication thanks to a unified 3D model representing the project's physical features and functionality. Users can utilize and update this model throughout the design, construction, and operation phases, ensuring all relevant information is readily available. The earlier you implement BIM, the more significant its impact. As shown in Fig. 2 (the MacLeamy curve), the ability to influence costs and changes significantly decreases as the project progresses. Changes are cheapest during design but become much more expensive later. Curve 4 illustrates how BIM shifts this curve leftward, allowing for more cost-effective changes, at later stages. This shift requires interaction between all project phases [21].

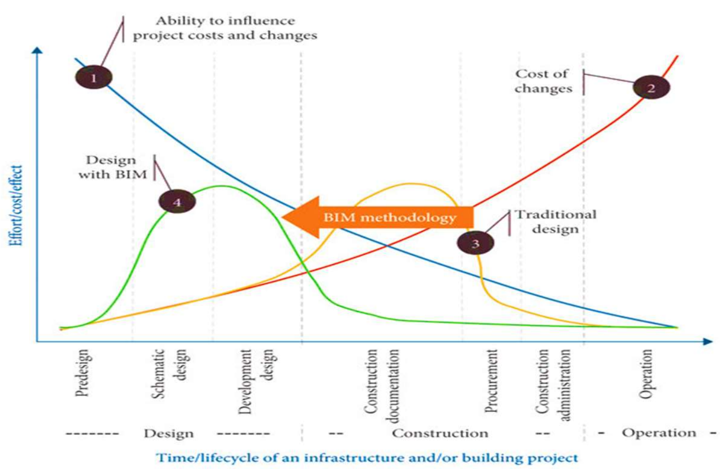

Fig.2. Relationship between BIM and Productivity/ Construction Performance [22].

METHODOLOGY

An extensive exploration across diverse databases and global journals was conducted to initiate this investigation, focusing on Building Information Modeling (BIM) and variation orders in the construction sector, explicitly emphasizing the cost aspect of BIM technology. This extensive review includes sources such as books, academic journals, articles, electronic journal databases, and conference proceedings. The selected methodology utilized a quantitative research strategy[7, 8], employing questionnaires to gather responses from several areas efficiently. The survey had five parts: questions about the participants' backgrounds; general questions about the importance and usefulness of BIM; specific questions about reducing variation orders, problems, and improvements; and optional extra questions. We assessed Parts 2, 3, and 4 using a Likert scale. We employed the quantitative research to demonstrate causal relationships between factual data and correlate them with previous studies. On the other hand, the qualitative design method involves interviews with BIM specialists in Jordan [23]. We evaluated the obtained data using the statistical program Minitab. The statistical study [24] incorporated descriptive data such as frequency, percentage, mean, and standard deviation[9]. Simultaneously, the survey targeted professionals in the construction field, focusing on individuals with expertise in BIM across various roles within Jordanian companies. This included stakeholders like contractors, consulting firms, owner representatives, and organisations associated with the construction sector, such as JEA, the Ministry of Public Works and Housing, and the Greater Amman Municipality [25]. We disseminated the questionnaire to engineers engaged in ongoing construction projects and employees of construction and consulting companies through physical copies. In addition, we distributed electronic copies of the questionnaire via email, social media platforms, and LinkedIn to reach engineers affiliated with companies in the construction sector. This combined methodology is the foundation for integrating quantitative and qualitative approaches for a comprehensive exploration.

Ninety-two participants were included in the sample population, while 123 questionnaires were returned—the distribution of questionnaires targeted engineers in various positions within the construction industry. The surveys were sent to a diverse range of companies using email and social media platforms. We effectively reached the required population sample, including contractors, consultants, and owners, by employing the Google Forms platform for the online questionnaire. The scope of this study specifically encompassed the pre-construction stage, spanning from stage 1 to stage 4. Decisions regarding designs and costs are often made during this early phase, making it a crucial stage with substantial influence on later construction stages. Inadequate design and cost advice at this juncture can result in complications during later stages, leading to redesigns, change orders, rework, and project alterations, as shown in **Fig. 3**.

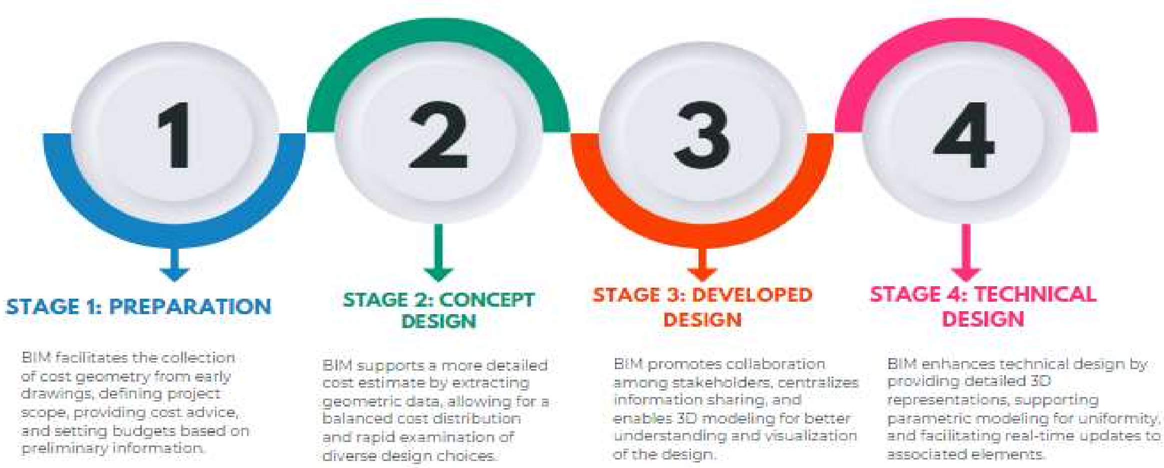

Fig. 3. Pre-Construction Phases Analyzed: Stages 1 to 4

Stage 1: Preparation Stage

Clients want to determine a budget before starting a project; therefore, they undertake feasibility studies. During this phase, we must provide cost estimates based on little information, such as basic sketches. By collecting cost geometry from early drawings, defining the project scope at an elemental level, providing professional cost advice to evaluate the project's viability, and setting a budget, BIM speeds up the creation of initial concept estimates. While the cost estimate is simple at this point, it considerably impacts the final cost [26].

Stage 2: Concept Design

At this step, the design team creates the design in greater detail after determining the cost range during the feasibility stage. BIM aims to produce a more detailed cost estimate based on a more developed design to confirm the budget established at the feasibility stage. The cost plan is offered to demonstrate the cost allocation to major construction parts. BIM will extract as much geometric data as possible based on the data available in the model to provide preliminary cost estimates and achieve a balanced cost distribution. Furthermore, BIM can accelerate cost estimation preparation, particularly for diverse design choices. This capability allows for the rapid and precise examination of various design possibilities, allowing the client to select the best design that matches his or her needs. Traditional working methods are possible, but the procedure is difficult, time-consuming, and error-prone [27].

Stage 3: Developed Design

Design develops at this stage as more comprehensive information becomes available. BIM allows collaboration among various design stakeholders, such as architects, engineers, and contractors. It offers a centralized platform for all team members to collaborate, share information, and make real-time adjustments, resulting in more integrated and cohesive design creation. Simulation and visualization BIM allows for 3D modelling, enabling designers to build visual representations of their projects. This helps to understand the design better, develop it, and make educated decisions. Furthermore, BIM allows simulations to ensure the design fits various criteria and standards. Moreover, BIM facilitates simulations, guaranteeing that the design conforms to many requirements and standards.

Building Information Modelling (BIM) significantly improves technical design by digitally representing a building or infrastructure's physical and functional attributes. BIM enables the generation of complex 3D models that accurately represent the components of a building or structure. This enables technical personnel to visualize the interaction and integration of multiple components easily. BIM simplifies parametric modelling in technical design, allowing for immediate updates of interconnected pieces when modifications are made to one design area. The attribute ensures uniformity and precision throughout the model when changes are made, making it beneficial in technical design.

Unexpected changes, in the form of requests for modifications, regularly pose a risk to the financial stability of construction projects in Jordan. These unforeseen alterations greatly disturb timetables and budgetary arrangements. This study aims to address and evaluate the persistent issue of variation orders in Jordan's construction industry. This article provides a detailed comparison of different approaches utilized to assess the competence of construction companies in applying Building Information Modelling (BIM) technology [28,29]. Given the insufficiency of current models, we have created an innovative model that allows businesses to assess their BIM capabilities. This approach aims to reduce changes in requirements during every phase of a project's life cycle, including design, construction, and maintenance. By utilising Building Information Modelling (BIM), firms can optimise their operations and realise financial benefits. Engineers and industry professionals are given the ability to optimise this model by carefully adjusting it using real-world data. This methodology seeks to assess building information modelling (BIM) capacities methodically. Moreover, its objective is to offer a comprehensive instrument that effectively reduces modifications to construction plans in the Jordanian construction sector. The objective is to create a proficient and proactive approach to project management, resulting in enhanced efficiency and cost-effectiveness in the construction sector in Jordan. To efficiently handle unexpected variation orders, relying on a precise tool rather than random solutions is necessary. The findings are expected to aid in making well-informed judgements on the evaluation model, addressing issues associated with changes in requirements, and fostering an age of efficient, predictable, and satisfactory projects for clients [30.31].

The data shown in Table 1 is derived from thoroughly examining the literature before the survey. The table provides a thorough and comprehensive overview of the various research fields that contribute to the extensive study of building information modelling (BIM) in Jordan's construction industry. The primary emphasis, "BIM Capability," comprises the critical areas of investigation in the study. This publication delves into the importance of Building Information Modelling (BIM) in improving building project outcomes and fostering collaboration among stakeholders. The study has a specific goal of reducing the occurrence of change requests in construction projects. This objective targets explicitly certain areas of BIM implementation. These include the identification of conflicts prior to construction, the detection of conflicts, and the impact of visualisations and simulations in the Building Information Modelling (BIM) process. Understanding the main components of BIM is crucial for optimising building processes, minimising errors, and reducing variation orders [31]

The survey not only addresses the technical issues but also explores the challenges and possible improvements related to the integration of BIM. This entails the synchronization of several fields, the surmounting of proficiency and operational obstacles, and the allocation of resources for BIM software and training. The successful and efficient utilisation of BIM in the building sector in Jordan relies on the following important aspects: The study broadens its scope to evaluate the significance of owner and customer support in ensuring the success of BIM implementation. Furthermore, the report specifically examines BIM's impact on building sector advancements. The survey concludes by examining the barriers to adopting Building Information Modelling (BIM) in Jordan, including lack of knowledge, legal constraints, and government support. Table 1 elaborates on the many study areas concerning Building Information Modelling (BIM) in Jordan's building industry. It notably emphasizes variation orders and the problems they entail. It functions as a comprehensive manual for comprehending the intricate investigation of this subject [32,33].

Table 1 Building Success in Jordan: BIM's Impact on Projects, Collaboration, and Challenges.

No.	Category	Assessing the Building Information Modeling Capability to Mitigate Variation Orders in the Jordanian Construction Industry.	Code
1	BIM Confidence	Building Information Modeling (BIM) is essential for enhancing construction project outcomes in Jordan.	A1
		Strengthening Stakeholder Collaboration in Jordanian Construction with BIM Implementation.	A2
		Examining Confidence Levels in BIM's Contribution to Efficiency and Productivity in Jordanian Construction	A3
2	Specific to reducing variation orders	"Enhancing Pre-construction Clash Identification in Jordanian Projects: The Role of Building Information Modeling (BIM)."	B1
		Reducing Rework and Change Orders in Jordanian Construction with BIM-Based Clash Detection.	B2
		The Impact of Visualizations and Simulations in BIM for Jordanian Construction Projects	B3
		BIM's Potential in Minimizing Design Changes and Variation Orders in Jordanian Construction	B4
3	Challenges and improvements	Challenges in Integrating BIM Across Disciplines in Jordanian Construction Projects.	C1
		Overcoming Skill and Workflow Challenges: The Hindrance of Effective BIM Implementation in Jordanian Construction Projects.	C2
		investing in BIM: Examining the Role of Software and Training in Jordan's Construction Industry	C3
		Owner and Client Support: A Key Factor for Successful BIM Implementation in Jordanian Construction.	C4
4	Jnderstanding BIM's Impact on Changes in Jordanian Construction	Comparative Analysis: BIM vs. Traditional Methods in Minimizing Variation Orders in Jordanian Construction Projects	D1
		Barriers to BIM Adoption in Jordan: Lack of Knowledge, Legal Regulations, and Policymaker Support	D2
		Lack of support from policymakers: Standards and codes are not available	D3
		The absence of government support and the reluctance of officials to change and progress	D4

Data and analysis

This investigation employs quantitative methods to explore the association between Building Information Modeling (BIM) implementation and project efficiency within the Jordanian construction industry. The study uses a graphical representation and regression analysis to investigate the influence of specific BIM functionalities on overall project efficiency and productivity, as shown in **Table 2.** The analysis demonstrates significant positive correlations between BIM's collaborative features, clash detection capabilities, and error prevention potential, contributing to enhanced project efficiency [31]. Statistically significant findings further solidify this connection, highlighting the potential of BIM to optimize project outcomes. However, the analysis also acknowledges potential challenges associated with changes. It suggests that further research and implementation strategies focused on optimizing BIM workflows could unlock its full potential in the Jordanian construction industry.

Table 2 Results of Cause Analysis

No.	Category	Code	Mean	Rank within category	Rank Cross-category	standard deviation
1	BIM Confidence	A1	3.5263	1	7	1.4532
		A2	3.5128	2	8	1.4373
		A3	3.4210	3	11	1.4646
2	Specific to reducing variation orders	B1	3.4024	3	12	1.2705
		B2	3.3461	4	15	1.4163
		B3	3.6	2	4	1.4002
		B4	3.6447	1	3	1.5035
3	Challenges and improvements	C1	3.3809	4	13	1.5370
		C2	3.45	3	10	1.2103
		C3	3.5411	2	5	1.3827
		C4	3.6463	1	2	1.1869
4	Understanding BIM's Impact on Changes in Jordanian Construction	D1	3.9239	1	1	1.6103
		D2	3.456	3	9	1.5265
		D3	3.532	2	6	1.4853
		D4	3.347	4	14	1.6342

Fig. 4 captures the intriguing dynamics within the perceptions of Jordanian construction professionals regarding BIM and its influence on their confidence in project efficiency.

The upward trajectory, reflected in the positive coefficient for X3 (BIM's effectiveness in clash identification), establishes a clear correlation: heightened proficiency in detecting clashes before construction increases confidence in efficiency improvements. Similarly, the positive association observed with X1 (agreement on enhanced communication through BIM) underscores collaboration as a significant contributing factor. However, a minor decline linked to X2(confidence in BIM's role in efficiency enhancement) suggests some uncertainty, indicating a potential need to address concerns about last-minute changes or knowledge gaps. The illustration underscores the importance of prioritizing BIM's conflict-prevention and collaborative capabilities to enhance confidence and facilitate smoother, more efficient project outcomes [33].

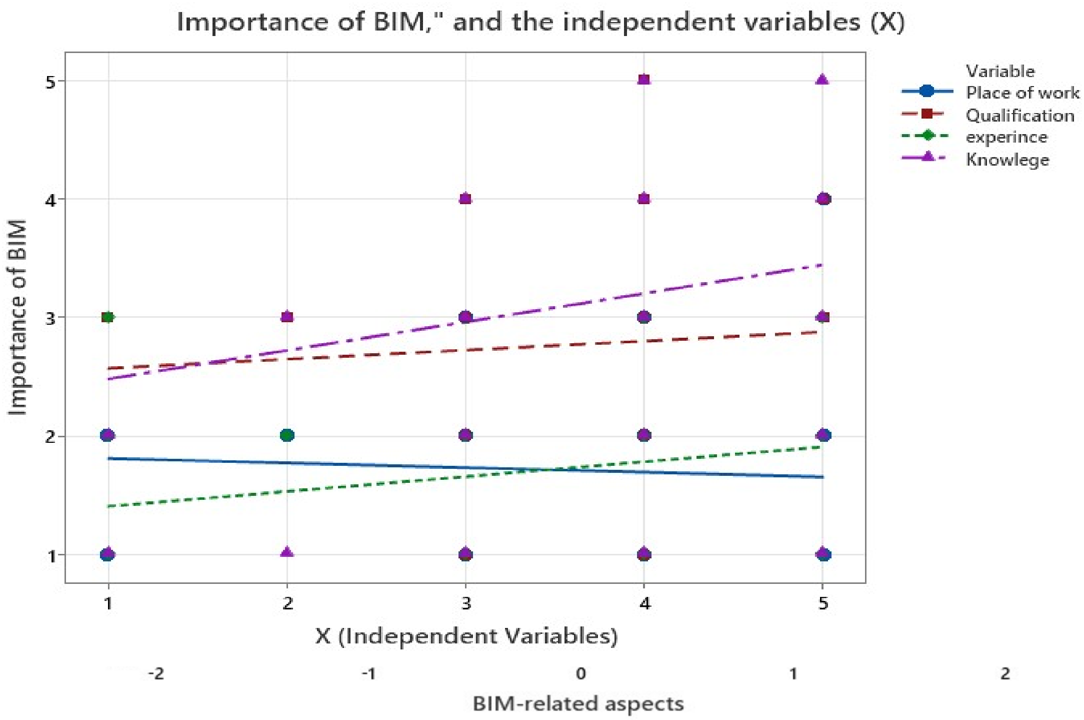

Fig.4. Comparison of the Importance of BIM for improving construction project outcomes in Jordan.

This case study delves into the efforts of the Jordanian construction industry to leverage the potential of BIM while mitigating the impact of costly variation orders. The analysis, depicted in the accompanying figure, uncovers an intriguing interplay involving teamwork, client endorsement, and challenges in implementation. **Fig. 5** illustrates how robust teamwork, particularly among those recognizing the long-term benefits of BIM, significantly enhances the perceived effectiveness in reducing variation orders [34]. Conversely, obstacles such as knowledge gaps and unclear workflows emerge as prominent challenges in implementation, underscoring the necessity for targeted solutions. Notably, the figure highlights client endorsement as a pivotal factor in optimising the success of BIM, facilitating smoother project execution and minimising variation orders. This data-driven exploration underscores the substantial potential of BIM to revolutionize the Jordanian construction landscape, emphasizing the significance of promoting collaboration, addressing knowledge gaps, and securing client engagement for a future characterized by efficient and streamlined projects.

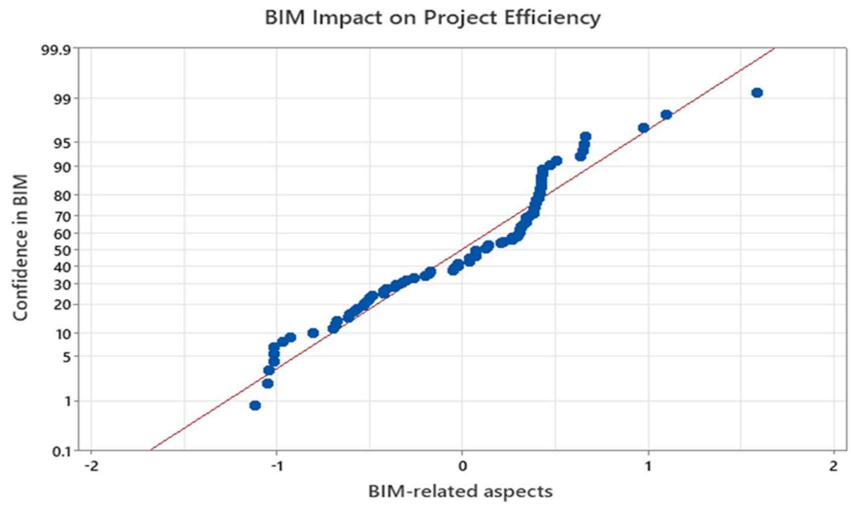

Fig.5. Regression of Teamwork Confidence and BIM's Impact on Change Orders in Jordanian Construction

Fig. 6 encapsulates our meticulously crafted model, strategically devised to tackle and mitigate variation orders effectively within the unique landscape of the Jordanian construction industry. Through a visual representation, this model offers a clear and systematic framework to guide stakeholders through managing variation orders across diverse stages of a project's life cycle. By presenting the interconnected components and processes, **Fig. 6** is a valuable visual reference, empowering industry professionals and decision-makers to navigate the challenges associated with variation orders in Jordanian construction projects.

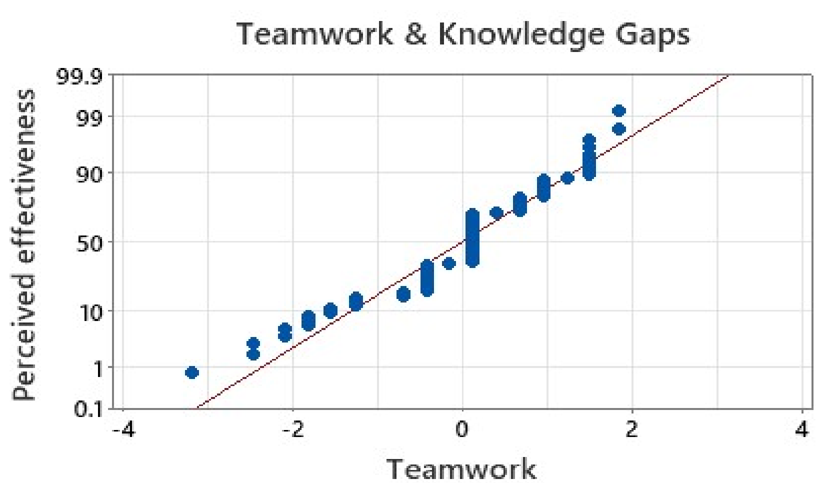

Fig. 6. Regression Analysis of Building Information Modeling (BIM) Impact on Jordanian Construction

As illustrated in **Fig. 7** in the second section of the questionnaire, the data presented indicates a compelling correlation between the utilisation of Building Information Modeling (BIM) and its efficacy in pinpointing variation orders prior to the commencement of construction in Jordanian projects. These findings underscore the significance of collaborative teamwork facilitated by BIM across diverse professional domains. It suggests that fostering collaboration among various professions through BIM can substantially mitigate errors and omissions. Consequently, this collaborative approach has the potential to minimise the occurrence of last-minute design alterations and subsequent variation orders in the realm of Jordanian construction projects.

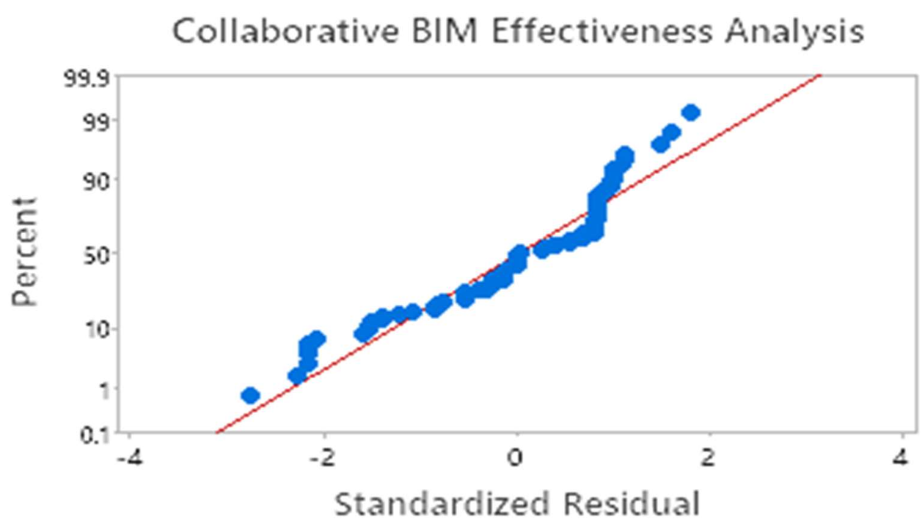

Fig. 7. Analyzing the Collaborative Efficacy of BIM in Preemptively Identifying Variation Orders.

As illustrated in **Fig. 8** in the questionnaire's third segment, the data reveals challenges faced in effectively utilising Building Information Modeling (BIM) in Jordan. The statistics emphasise hurdles arising from insufficient knowledge and unclear processes. Additionally, they emphasise the crucial importance of obtaining support from building owners and clients for the prosperous implementation of BIM. The necessity of securing approval from these stakeholders is intricately tied to the overall triumph of BIM adoption, highlighting its essential contribution to optimising advantages in the realm of Jordanian construction projects.

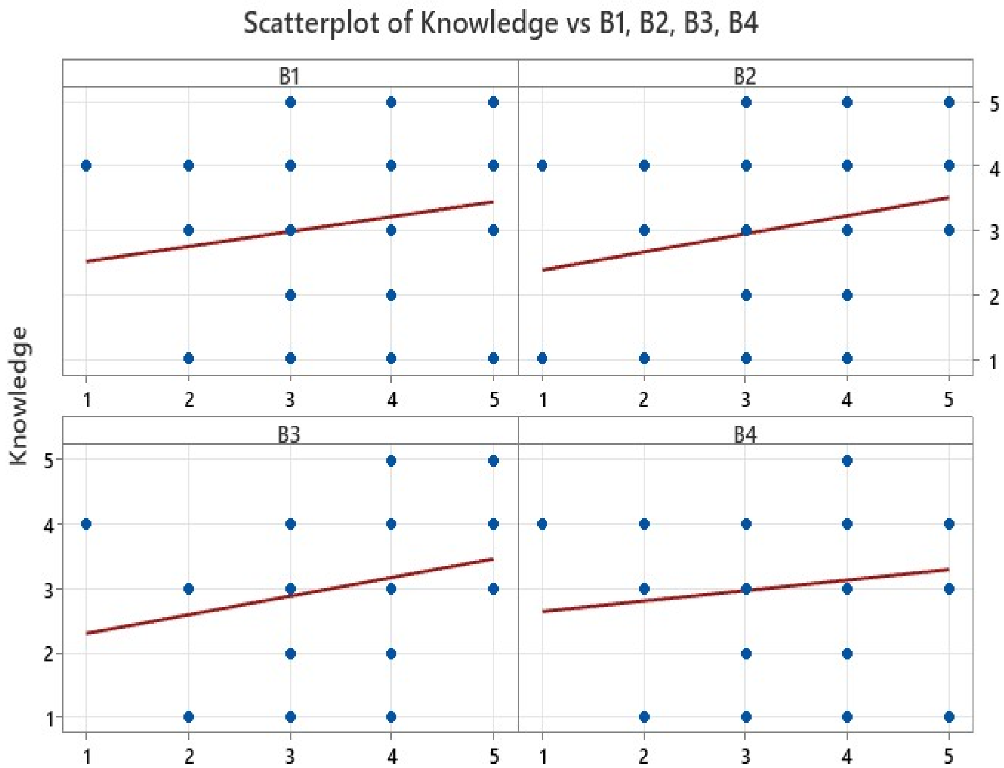

Fig.8. Knowledge Levels and BIM Integration Challenges in Jordanian Construction Projects

As shown in Fig. 9, The comparison between the traditional and Building Information Modeling (BIM) approaches in construction project management reveals significant differences. The traditional approach often grapples with unclear plans, delayed decisions, inadequate planning, deficient scheduling, and communication gaps, resulting in costly rework, variation orders, and delays. In contrast, the BIM approach utilises 3D modelling and digital tools to proactively identify and address issues early in construction, leading to minimised rework, variation orders, and delays. Overall, the BIM approach enhances project efficiency and cost-effectiveness by improving communication, reducing errors in design documents, providing accurate cost estimates and schedules, enhancing constructability, and minimising waste and environmental impact.

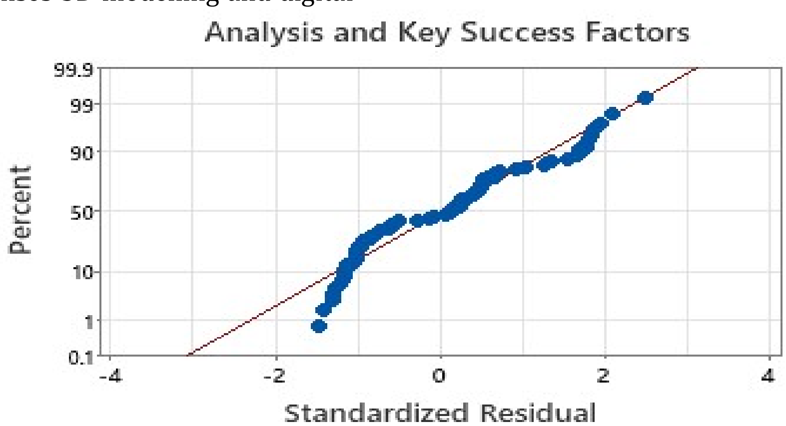

Fig. 9. BIM Challenges in Jordan: Analysis and Key Success Factors

Our research aims to bolster Building Information Modeling (BIM) capability as a strategic tool for mitigating variation orders in the Jordanian construction industry. The assessment model is initiated by identifying the root causes of variation orders, as shown in Fig.10, and categorising them into client changes, contractor errors, project-specific considerations, and external factors. Customisation of the model follows, tailored to the unique characteristics of each construction project while emphasising stakeholder collaboration among architects, engineers, contractors, and clients to collectively address and mitigate identified factors. The assessment model devised for this purpose encompasses eight key steps, as shown in **Fig. 11**. The model advocates for establishing quantitative metrics, incorporating parameters such as cost overruns, project delays, and design changes. Leveraging BIM capabilities encourages early risk analysis and identifying potential changes to minimise their impact and reduce variation orders. Integrating efficient change management protocols, visual collaboration for swift decision-making, and alignment with the organisation's BIM maturity level are crucial model components. Emphasising the early design phase as pivotal, the research aims to significantly reduce variation orders in the Jordanian construction industry by enhancing BIM capabilities and the comprehensive implementation of the assessment model[35].

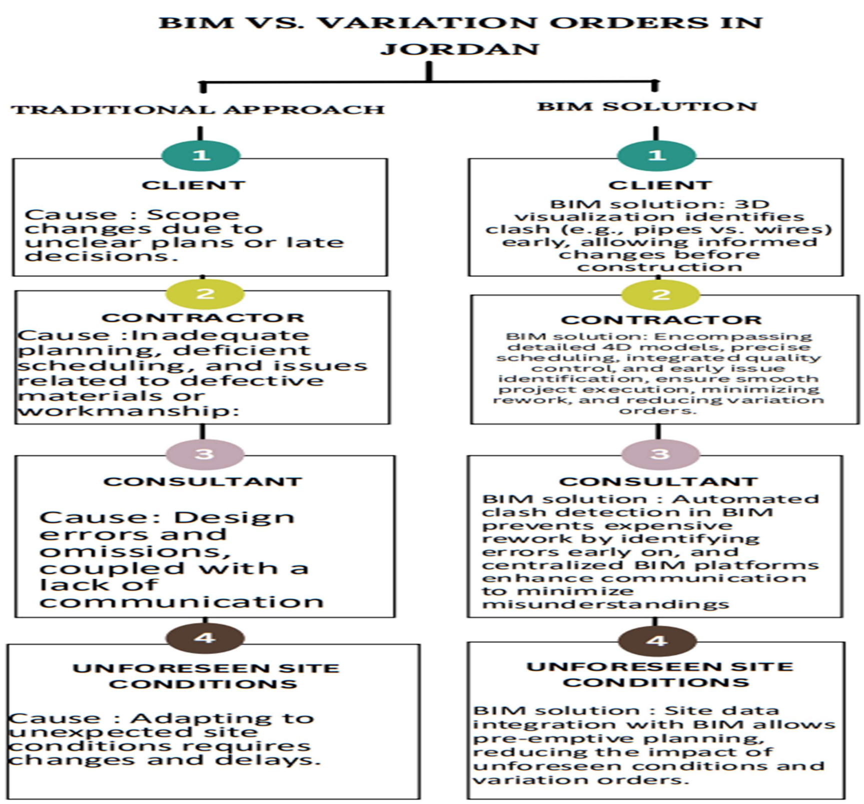

FIG. 10. Causes with BIM Solutions for Enhanced Project Results in the Jordanian Construction Industry

A BIM Model for Mitigating Variation Orders in the Jordanian Construction Industry

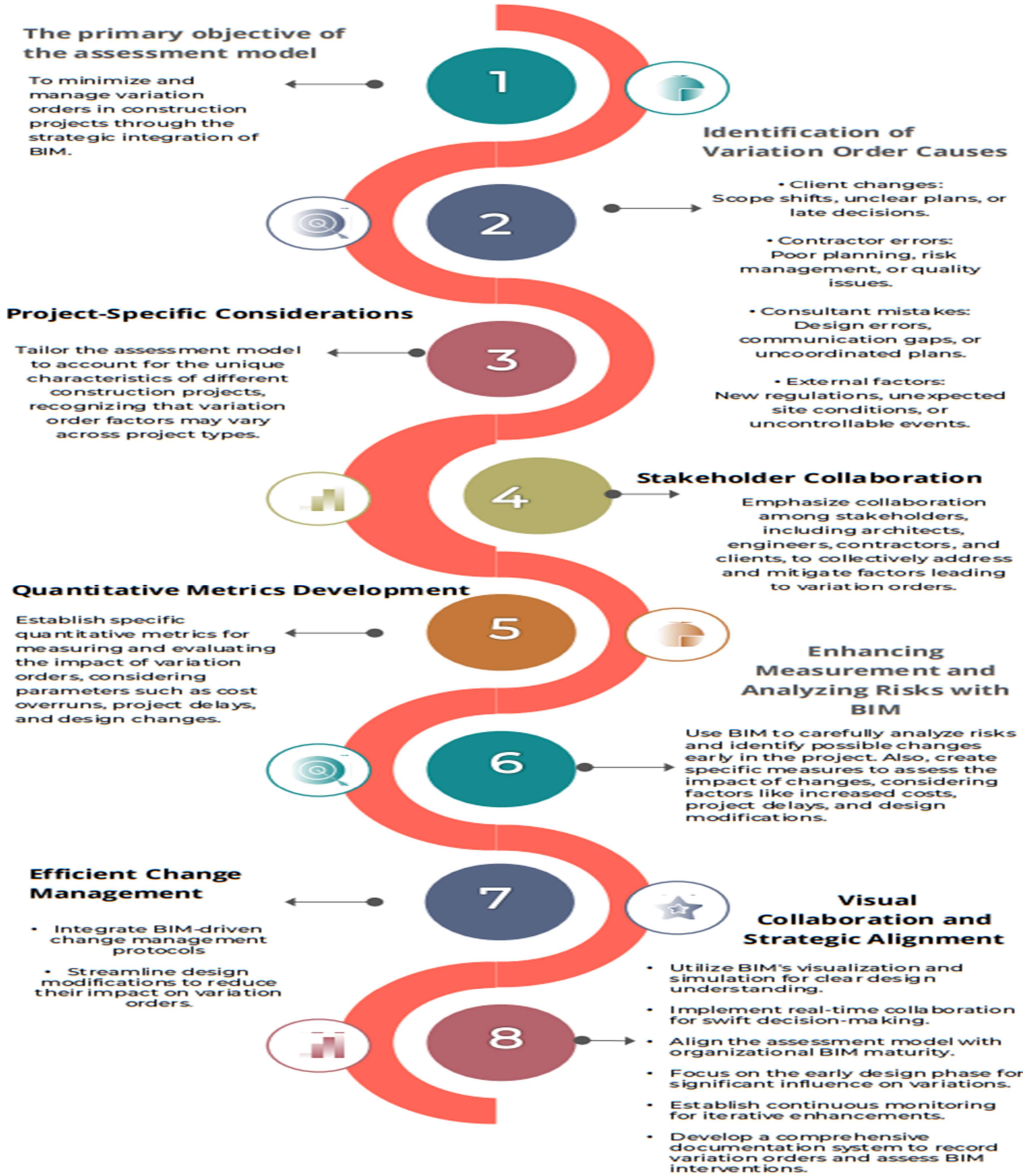

Fig. 11. A BIM Model for Mitigating Variation Orders in the Jordanian Construction Industry

CONCLUSION AND RECOMMENDATIONS

This study aims to promote using Building Information Modelling (BIM) as an essential tool for minimizing changes to construction plans in the Jordanian construction sector. This will be achieved by creating a comprehensive evaluation framework. This technique comprises eight essential components. It emphasizes the significance of identifying the fundamental factors, tailoring the project to its specific requirements, engaging with relevant parties, establishing quantifiable benchmarks, conducting early risk assessment via BIM technology, and integrating efficient change management procedures. The objective of our study is to enhance proficiency in BIM (Building et al.) to reduce the occurrence of variation orders efficiently. We place particular focus on the significance of the initial design process in attaining this objective. The comparison between traditional and BIM approaches demonstrates the advantage of BIM in improving project efficiency and cost-effectiveness. BIM accomplishes this by avoiding rework, variant orders, and delays by proactively identifying defects. This study highlights the revolutionary potential of BIM in reorganizing construction project management processes in Jordan. It advocates a shift towards advanced and collaborative techniques to assure ongoing industry advancement.

This work successfully constructed a model to minimize variance orders in the construction industry in Jordan. Throughout the research process, certain limitations were identified:

1- There is a scarcity of material regarding utilizing Building Information Modelling (BIM) in Jordan, specifically regarding change orders and BIM.

2- A recommendation for future investigation is to conduct action research to assess the adoption process and the benefits of BIM directly.

An inquiry on BIM and its impact on change orders in medium and small organizations and businesses beyond the construction sector.

Additional research is recommended to examine the influence of BIM on other variables associated with modification orders, such as time delays and disputes.

5- Performing extensive interdisciplinary and international research to enhance comparability and generalizability.

These limitations provide valuable insights for future studies to go deeper into and improve the comprehension of BIM implementation and its capacity to decrease change order expenses in Jordan and globally. This study sheds light on the persistent problem of variation orders (VOs) in Jordan's construction sector. These VOs are attributed to design defects, modifications demanded by clients, and communication gaps; traditional methods are inadequate, emphasizing the substantial influence of Building Information Modelling (BIM) as a viable solution for minimizing variations orders (VOs) and enhancing project outcomes. However, Jordan encounters obstacles that hinder the realization of BIM's benefits, including a lack of expertise and inadequate infrastructure. The extensive use of 2D CAD and Revit and the absence of a conducive regulatory framework impede progress. Prompt intervention is crucial.

REFERENCES

[1] Melnikovas A. Towards an Explicit Research Methodology: Adapting Research Onion Model for Futures Studies. Journal of futures Studies. 2018;23(2).

[2] Ja'far, A. A. (2018). The role of building information modeling design application in mitigating the variation order in the Jordanian construction industry. http://umpir.ump.edu.my/id/eprint/25608/

[3] Alshdiefat, A. (2018b). Developing an assessment model for adopting building information modeling to reduce the cost of change orders in the Jordanian construction industry. https://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.741153

[4] Khohar, H. A., Rahman, R. A., Haron, A., & Esa, M. (2021). Assessment strategies to evaluate building information modeling capabilities of organizations. *IOP Conference Series: Earth and Environmental Science*, *641*(1), 012012. https://doi.org/10.1088/1755-1315/641/1/012012

[5] Handayani, T. N., Likhitruangsilp, V., & Yabuki, N. (2019). A Building Information Modeling (BIM)-Integrated system for evaluating the impact of change orders. *Engineering Journal*, *23*(4), 67–90. https://doi.org/10.4186/ej.2019.23.4.67

[6] Abuaddous, M., Al-Btoosh, J. A. A., Al-Btoush, M. A., & Alkherret, A. J. (2020). Building information modeling strategy in mitigating variation orders in road projects. Civil Engineering Journal, 6(10), 1974–1982. https://doi.org/10.28991/cej-2020-03091596

[7] Chen, Z., Zhou, M., Chin, K., Darko, A., Wang, X., & Pedrycz, W. (2023). Optimized decision support for BIM maturity assessment. *Automation in Construction*, *149*, 104808. https://doi.org/10.1016/j.autcon.2023.104808

[8] Yılmaz, G., Akçamete, A., & Demirörs, O. (2019). A reference model for BIM capability assessments. *Automation in Construction*, *101*, 245–263. https://doi.org/10.1016/j.autcon.2018.10.022

[9] Chen, Z., Zhu, Z., Wang, X., Chiclana, F., Liu, X., & Skibniewski, M. J. (2023). Multiobjective Optimization-Based collective Opinion generation with fairness concern. *IEEE Transactions on Systems, Man, and Cybernetics*, *53*(9), 5729–5741. https://doi.org/10.1109/tsmc.2023.3273715

[10] Al-Btoosh, J. A. A. (2021). Building Information Modelling Technology in Mitigating Cost Overruns and Change Orders in Construction Projects. *Journal of Advanced Sciences and Engineering Technologies*, *4*(1), 50–64. https://doi.org/10.32441/jaset.04.01.05

[11] McCuen, T., Suermann, P. C., & Krogulecki, M. J. (2012). Evaluating Award-Winning BIM projects using the National Building Information Model Standard Capability Maturity Model. *Journal of Management in Engineering*, *28*(2), 224–230. https://doi.org/10.1061/(ASCE)me.1943-5479.0000062

[12] Wang, A., Su, M., Sun, S., & Yu-Qin, Z. (2020). A model of BIM application capability evaluation for Chinese construction enterprises based on interval grey clustering analysis. *Journal of Asian Architecture and Building Engineering*, *20*(2), 210–221. https://doi.org/10.1080/13467581.2020.1782214

[13] Edirisinghe, R., Pablo, Z., Anumba, C. J., & Tereno, S. (2021). An Actor–ActorNetwork approach to Developing a Life Cycle BIM Maturity Model (LCBMM). *Sustainability*, *13*(23), 13273. https://doi.org/10.3390/su132313273

[14] Tan, T., Mills, G. R., Papadonikolaki, E., & Liu, Z. (2021). Combining multi-criteria decision making (MCDM) methods with building information modeling (BIM): A review. *Automation in Construction*, *121*, 103451. https://doi.org/10.1016/j.autcon.2020.103451

[15] Yılmaz, G., Akçamete, A., & Demirörs, O. (2023). BIM-CAREM: Assessing the BIM capabilities of design, construction, and facilities management processes in the construction industry. *Computers in Industry*, *147*, 103861. https://doi.org/10.1016/j.compind.2023.103861

[16] Lumbera, L., & Silva, D. (2023). Roadmap for the Building Information Modeling Implementation: Structured plans to achieve High-Level Strategic Maturity in the Philippines' construction industry. In *Lecture notes in civil engineering* (pp. 703–718). https://doi.org/10.1007/978-981-99-4049-3_54

[17] Handayani, T. N., Likhitruangsilp, V., & Yabuki, N. (2019b). A Building Information Modeling (BIM)-Integrated system for evaluating the impact of change orders. Engineering Journal, 23(4), 67–90. https://doi.org/10.4186/ej.2019.23.4.67

[18] Edirisinghe, R., Pablo, Z., Anumba, C. J., & Tereno, S. (2021b). An Actor–ActorNetwork approach to Developing a Life Cycle BIM Maturity Model (LCBMM). Sustainability, 13(23), 13273. https://doi.org/10.3390/su132313273

[19] Zuhairi, A. H., Marshall-Ponting, A., Ahmad, T., Nasly, M. A., & Zahrizan, Z. (2014). Exploring the barriers and driving factors in implementing Building Information Modelling (BIM) in the Malaysian construction industry: a preliminary study. *Journal of the Institute of Engineers, Malaysia*, *75*(1). https://doi.org/10.54552/v75i1.36

[20] Ababneh M, Alzubi M. Engineering management for Assessment of Solar Energy Development (a case study of Jordan). Journal of

Advanced Sciences and Engineering Technologies. 2023 Mar 15;5(2):34-50.

[21] Al-Btoosh, J. A. A. (2021b). Building Information Modelling Technology in Mitigating Cost Overruns and Change Orders in Construction Projects. *Journal of Advanced Sciences and Engineering Technologies*, *4*(1), 50–64. https://doi.org/10.32441/jaset.04.01.05

[22] Van Tam N, Quoc Toan N, Phong VV, Durdyev S. Impact of BIM-related factors affecting construction project performance. International Journal of Building Pathology and Adaptation. 2023 Apr 14;41(2):454-75.

[23] Noruwa, B. I., Arewa, A., & Merschbrock, C. (2020). Effects of emerging technologies in minimizing variations in construction projects in the UK. *International Journal of Construction Management*, *22*(11), 2199–2206. https://doi.org/10.1080/15623599.2020.1772530

[24] Panya, D. S., Kim, T., & Choo, S. (2023). An interactive design change methodology using a BIM-based Virtual Reality and Augmented Reality. *Journal of Building Engineering*, *68*, 106030. https://doi.org/10.1016/j.jobe.2023.106030

[25] Kim, K., Park, J., & Cho, C. (2020). Framework for Automated Generation of Constructible Steel Erection Sequences using Structural Information of Static Indeterminacy Variation in BIM. *KSCE Journal of Civil Engineering*, *24*(11), 3169–3178. https://doi.org/10.1007/s12205-020-

[28] Maraqa, M. J., Sacks, R., & Spatari, S. (2021). Quantitative assessment of the impacts of BIM and lean on process and operations flow in construction projects. *Engineering, Construction and Architectural Management*, *28*(8), 2176–2198. https://doi.org/10.1108/ecam-12-2020-1068

[29] Faten Albtoush, A., et al., Factors affecting the cost management in construction projects. International Journal of Civil Engineering and Technology, 2020. 11(1).

[30] Albtoush, F., et al. Factors Affecting the Accuracy of Cost Estimate in Construction Projects: A Review. in Proceedings of the National Conference for Postgraduate Research (NCON-PGR 2020), Virtual Mode. 2020.

[31] Ja'far, A., et al., MATERIAL WASTE IN CONSTRUCTION PROJECTS: CAUSES AND EFFECTS. Journal of Southwest Jiaotong University, 2023. 58(3).

[32] Al-Btoush, M.A., et al. Adoption approaches for BIM implementation in construction projects: Jordan as a case study. in AIP Conference Proceedings. 2023. AIP Publishing.

[33] Tasnim, S., et al., A Comprehensive Review of Flexible Pavement Failures, Improvement Methods and Its Disadvantages. Key Engineering Materials, 2021. 879: p. 136-148.