The importance of applying digital twin technology and its obstacles in engineering projects in Syria

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Abstract

This study focuses on defining the industrial revolution and digital transformation, including their associated technologies and how they have impacted the fields of industry and construction. Additionally, it delves into the concept of digital twin technology, exploring its origins, definition, stages, maturity levels, and scale. The study also examines the components of digital twin technology, its ecosystem, characteristics, and key features of its application. Specifically in the field of construction, it discusses the components of digital twin technology and their overlap with building information modeling throughout a building's life cycle. The study emphasizes the importance of data in shaping digital twin models and outlines relevant standards. It also highlights various digital twin platforms used in construction along with machine learning algorithms employed in these systems. Finally, it explores how digital twin technology is used in construction projects and outlines its benefits while also identifying key obstacles to its implementation in engineering projects.

The objective of this study is to assess the level of familiarity among workers in the construction industry in Syria with digital twin technology, their understanding of its application, and the primary obstacles to its implementation in engineering projects. A descriptive approach was employed, and a questionnaire was distributed to 36 participants with varying levels of education and engineering experience. The Likert scale was used to evaluate responses, and statistical software SPSS was utilized for quantitative analysis. The findings indicate a low level of awareness and knowledge regarding digital twin technology, resulting in limited comprehension of its significance and relevance in engineering projects. This may be attributed to inadequate exposure to new research and studies as well as the country's crisis. The study concludes with recommendations such as prioritizing training for construction workers, enhancing infrastructure, and conducting additional research on digital twin technology within the construction sector.

Keywords: the fourth industrial revolution; Digital Twins; BIM; construction industry; digital transformation

1. Introduction

The construction and engineering industry is in constant need of development, particularly after the fourth industrial revolution and the technological advancements that came with it. This includes modern technologies like big data, artificial intelligence, 3D printing, the Internet of things, digital twin, and others. The integration of these technologies in the field of engineering and construction is a top priority for countries, governments, and companies due to their numerous benefits that can help solve problems and accelerate development. The lifecycle of a building primarily consists of the design, construction, operation, maintenance, and end of life stages where each stage can be divided into superimposed information layers that require efficient information exchange strategies for interoperability across all lifecycle stages [1]. Information regarding design details needs to be exchanged between different engineering team members during the design stage, and different stakeholders need to communicate design and construction progress with each other during the construction phase [2]. In addition, the building operation and facility management teams need to obtain feedback from the building facilities and occupants during operation [3, 4]. A significant effort must therefore be invested to achieve efficient information

DOI: https://doi.org/10.54216/IJBES.080201
Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

update and exchange throughout a building's life cycle. The concept of the Digital Twin originated from the aerospace field [5], and then expanded to industrial manufacturing [6, 7, 8, and 9], has attracted increasing attention in the built environment domain in recent years. Existing studies have adopted BIM and IoT technologies for many aspects such as esigning a building, monitoring, and management of construction processes, building facilities, and indoor environment management [8, 9, 10].

As the world moves towards the creation of a unified digital realm, known as the Metaverse, engineers can now generate 3D models that interact within a digital environment capable of hosting any virtual model. This technology has numerous applications, particularly in the field of Digital Twin technology, which involves creating a digital environment that replicates physical objects and simulates reality to a significant degree. This interactive digital environment is connected to the real world and synchronizes with databases in real-time, allowing for graphical analysis and providing an ideal solution for reviewing large projects without incurring construction costs or time delays. The Digital Twin is revolutionizing how buildings are planned, constructed, used and managed by enabling them to operate at unprecedented levels of efficiency, safety and comfort. By installing sensors throughout facilities and analysing data collected from them, buildings can respond intelligently to their surroundings and work together with other buildings and infrastructure to achieve long-term benefits. The digital twin technology has many advantages, which can be upgraded and developed, and is highly efficient in rationalizing energy consumption and is described as environmentally and human-friendly.

2. Research Methodology

To achieve the research objectives, an analytical descriptive approach was employed, utilizing a questionnaire tool to gather data from a diverse sample of parties involved in projects construction in Syria. This sample included engineers, consultants, contractors, and technical training workers. The purpose of the questionnaire was to analyse the relationship between various research hypotheses and determine the level of awareness regarding digital twin technology and the obstacles to its application locally. The questionnaire was designed with multiple-choice questions that encompassed all aspects of the research, including the respondent's job nature, awareness level of digital twin technology, its significance, and obstacles. Previous studies and research hypotheses informed the questionnaire's development.

3. What is BIM?

BIM (Building Information Modelling) is the process of designing and building collaboratively using one coherent system of computer models. Instead of separate sets of drawings that are used by various design professionals, BIM offers a 3-D or 4-D, interactive model of a building systems and assemblies.

In AEC industry, BIM plays a vital role during all phases of a construction project; from planning, designing, construction testing and commissioning, to the final stage of handing over to facility management, its an important technology that has affected to almost all the disciplines, and can be applied to several topics, this fact makes of the building information models a shared knowledge resource. so developed countries have recognized the benefit of BIM [11],In spite of, the government and clients playing a vital role in the mandate of BIM, the mixed approach (top-down and bottom-up) is recommended to expedite BIM implementation[12] .using BIM with partnership agreements improves stakeholder behaviour in Construction Mega-Projects. Enhancing stakeholder relationships reduces disputes, eliminates conflict of interest, and allows sharing of knowledge, healthy interaction between project stakeholders, and improving problem-solving techniques [13].

BIM Champions, also known as "change leaders," are responsible for assessing the adoption of BIM and steering its progress in each location. In the UK, their approach involves incorporating it into their Plan of Work. These have proven to be a key element in measuring and assessing needs to enable the achievement of technology adoption[14].so they use six-step methodology to implement BIM namely; raising awareness; perceived benefits; AEC industry readiness, and organizations' capability; identifying the barriers; removing the barriers; and defining the key factors influencing the implementation[15].

Researcher s ahmed spoke in (2018) about the gradual transition to bim in Syrian companies and the possibility of applying bim in Syrian building projects In (2018) and also about bim improvement framework for Syrian Aec companies in (2019).[16] however, the adoption level of BIM remains much lower than expected [17]. Due to not only solving the massive problems with AEC industry projects and reaping the benefits from implementing BIM but also improving the project's performance and efficiency [18] , Currently, the Syrian AEC industry is witnessing the transformation from CAD to BIM so it must be encouraged by the government and other related firms and individual expertise to spread it as much as possible in order to keep up with the ever-evolving world of technology [19], in addition adoption of Building Information Modelling (BIM) has increased significantly over the last few years [20]

DOI: https://doi.org/10.54216/IJBES.080201
Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

4. What is Digital Twin?

Digital Twin concept came into being in relation to Product Lifecycle Management (PLM) in 2002 at the University of Michigan by Michael Grieves [21].
The proposed model has three components: real space, virtual space, and linking mechanism for the flow of data/information between the two; the model was then referred to as 'Mirrored Spaces Model' [22].

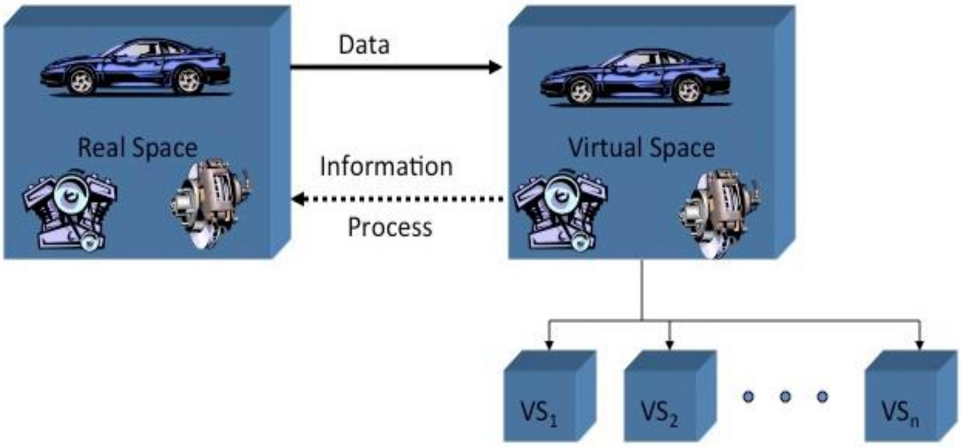

Figure 1. Concept of Product Lifecycle Management (PLM), Resource (Grieves, M.2016)

A similar concept in which software models mimic reality from information input from the physical world was imagined by David Gelernter in 1991 and was called 'Mirror Worlds' [23]
The name 'Digital Twin' (DT) first appears in NASA's draft version of the technological roadmap in 2010 [24].
Michael Grieves recently published research about the common misunderstanding that the Digital Twin does not exist unless there is a physical object [25]. According to Grieves, the primary criterion for determining if a digital model is a Digital Twin is whether the model is designed to become a physical product with a physical counterpart.

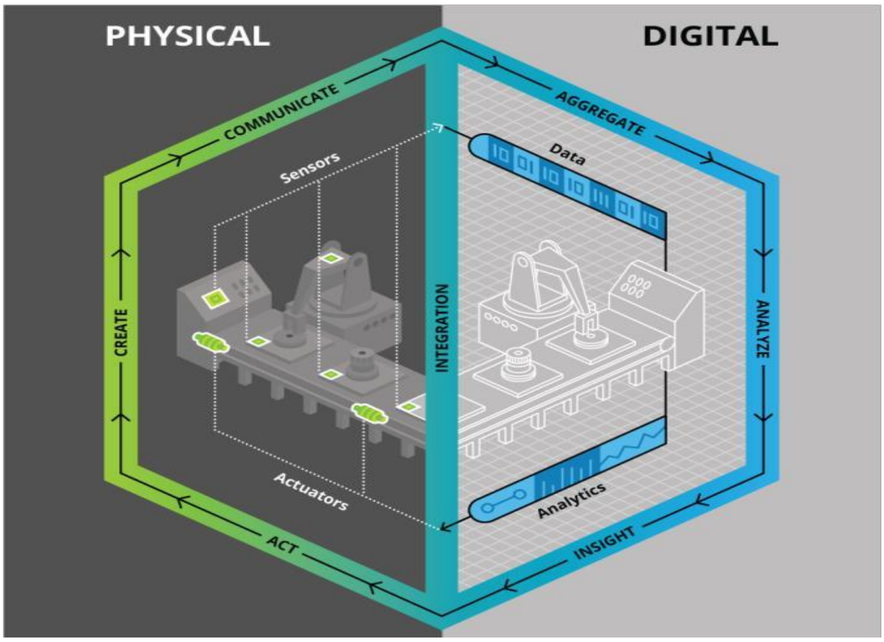

Figure 2. Digital Twin component, Resource (Deloitte University Press, 2017)

Digital Twin binds a virtual representation of a physical object is the bidirectional transfer or sharing of data between the physical counterpart and the digital one, including quantitative and qualitative data (related to material, manufacturing, process, etc.), historical data, environmental data, and most importantly, real-time data. Using these data, DT can perform such tasks as:

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Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

• In-depth analysis of physical twin.
• Design and validation of new or existing product/process.
• Simulate the health conditions of physical twin.
• Increase safety and reliability of physical twin.
• Optimization of part, product, process, or production line.
• Track the status of physical twin throughout its lifetime.
• Predict the performance of physical twin.
• Real-time control over physical twin.

5. Digital Twins in AEC.

Digital twin in building and architecture is a new dynamic, updated copy of a physical asset or group of assets – if it is a building, city or infrastructure – that combines design, construction and operating data in real time. Digital Twins simulate, predict, and inform decisions. Digital Twins can be thought of as an enhanced version of BIM that uses sensors, drones, and other inputs to gather information about a building. This data is then used to automatically update a digital model [26].
A digital twin can use advanced data analysis and artificial intelligence to continuously learn about a facility. This provides insights into how to best manage the building and its equipment. The concept can be used to analyse how building modifications affect performance, allowing for better investment decisions. From the foregoing, the use of digital twins can be considered as an effective tool to help project participants imagine the construction process and early detection of implementation problems. As well as a tool to communicate between parties and at the same time track the progress of construction for all steps of the construction process, from design and planning to management of procurement and construction [27].

A. Investment and projects marketing

A building's digital twin is a powerful marketing tool for real estate developers. Since there is an exact copy of the original building in a virtual environment, Potential customers and tenants can "visit" the project even before construction begins. They can walk around the building, even if the actual building isn't existed yet. Digital twins can be useful as sales tools for real estate companies, especially during health emergencies such as corona virus. However, landlords and tenants can "walk" Through the building together via virtual reality technologies. The project can be presented to financial institutions and potential investors [28]
Therefore, the digital twin can be relied upon as a tool for communication between parties in different disciplines and directions in the project. Building owners have many investment options, which they can use the digital twin to test. The results can then be compared, and the option with the highest return on investment found.

B. Design stage

The digital twin plays a major role in the production and creation of digital assets such as graphics, images, and different-dimensional models from BIM, as well as other types of design data and how they perform, including user behaviour, usage patterns, and space usage. This requires careful identification of the research object in order to know its data and record it to meet the requirements of use. The data must be validated and updated. A digital twin helps manage the comprehensive information of these assets and delivers them as a virtual representation containing graphical and computational data. Sensors (such as sensors, IoT devices, and asset and facility management system) assist in the process of accurately planning the sensor layer and integrating it into the design of the physical asset. This digital twin is updated regularly and can generate alerts when problems are detected. As well as assessing the structural integrity of materials over time as well as assisting in Preventing conflicts and increasing coordination between components of different systems. Using a digital twin can enhance the process of designing and creating digital assets. This happens in two ways:

1. Digital twins help designers and engineers' model, simulate, and implement what-if scenarios. To improve their design and development in an environment connected to reality that enables them to adapt the design of their assets to the existing assets and the surrounding environment. This is done at the level of individual assets, such as a building or an engineering unit. At the neighbourhood or city level.
2. Design can be inspired by data, information and evidence from various sources in a connected ecosystem that forms a close connection between the design, construction and operation of built environment assets. Digital Twin helps improve the operational efficiency of the built environment by integrating and automating historical data and information from early stages such as facility management and maintenance to improve the performance of the existing design. Incorporating historical data of implementations, asset management and facilities along with the use of digital twins can enhance the detailed design process. For example, a digital twin can be used at this stage to research environmental, social and governance standards before making investment decisions. A digital twin also allows simulations to be created of how the asset will work and how it will be used by end users. It also allows for the estimation of the cost, specifications and requirements of equipment for operations and assets.

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C. Construction stage

It is at this stage that the designed and mapped data about the asset is combined and large amounts of data are generated, updated, used, and stored during the construction process. Considering any changes captured by sensors, photos or video, point clouds, drones, laser scanning and can be incorporated into a virtual representation. The sensor layer (such as sensors, IoT devices, asset management system and facilities) is assembled and installed as part of the physical assets and marked on the virtual representation to transmit real data of operations and assets from the job site. BIM technology is integrated into almost every level of the business where it plays Multiple BIM dimensions play an important role in simplifying and organizing data and information management and estimating the time factor (4D-BIM) and cost (5D-BIM), which increases the possibilities of controlling the supply chain and tracking the necessary needs of the flow of materials and ready-made components and knowing the reserves in warehouses and suppliers. A building's digital twin can be used to simulate the construction process before any object is placed on site to detect inconsistencies, or overlaps between activities scheduled simultaneously, allowing for workflow conflict detection; Hence the optimization of the construction schedule. A construction simulation using a digital twin provides a better idea of how a project will use its budget throughout the construction phase [29].

This is useful for planning project procurement, when negotiating financing from external institutions and helps improve coordination. Among the parties involved in a project, construction simulation is useful for managing subcontractors where lack of coordination between trades is a frequent cause of delays and errors in construction projects. [30].

Project managers can analyse several potential cost-performance adjustments and select those that offer the most value to the project. In other words, many projects can be tested in a virtual environment without risk before the actual modification. One of the major challenges for construction managers is knowing the current status of a project in real time; the status of the project is constantly changing and the progress reports may not reflect the actual status of the project. Whereas when a digital twin is used during construction, it can be constantly updated with location information. There is no need for multiple visits by various interested parties, as they can simply check the digital form. Constantly updated [29].

With mobile devices, the use of drones can facilitate data collection and with the Internet of Things and laser scanners, engineers no longer need a constant physical presence on a construction site. Reducing website traffic is especially helpful during health emergencies [31].

D. Handover

The interoperability integrated with BIM models plays an important role for the facility in transferring and exchanging data in the design and implementation stages, and the importance of this data increases at the stage of facilities management and operation. In the digital twin system, this huge data is integrated, processed and diagnosed to reach the optimal solutions to avoid emergency problems and put the building in a state of readiness. A digital twin aggregates all delivery information into a coherent information form that is easy to access, use, and update during operation, maintenance, overhaul, and end-of-life phases, and promotes information management best practices and reduces risk.

E. Operations & Maintenance

The building uses many complex systems to maintain conditions suitable for use. A proactive maintenance approach is more efficient and less costly than fixing problems after they have occurred, and the digital twin model makes it easier to do this as it contains detailed information on all equipment and components, including their physical characteristics and cost; The model can reflect the exact condition of building elements, while showing problems such as mechanical wear or poor performance of equipment and devices. Digital twins can be used as simulation tools to analyse how a building will behave under different circumstances, including emergencies [32]. An updated digital twin provides a detailed snapshot of the building, and maintenance staff can schedule repairs off-peak. Artificial intelligence can also be used to analyse construction conditions in real time, predicting non-obvious problems and malfunctions, making planned maintenance more effective [28].

F. Stockholders

The lack of coordination between the different stakeholders leads to serious problems during the construction stages. Building information modelling plays a role in developing the entire facility with all specialties, through multiple BIM techniques. The digital twin comes to simulate the physical building, which makes it easier to get rid of any errors or inconsistencies. The digital twin can be used to analyse the building's dynamic response to changes in occupation or energy supply and indicates times for maintenance or modernization. This planning assists in optimal energy efficiency, cost savings, increased sustainability, and meets the desire of owners and operators. It allows cross-disciplines to simultaneously create a coordinated multi-disciplinary solution with early validation of design options detailed to improve the performance of the building. As a result, it is a more cost-effective, direct and sustainable design and construction process that leads to safer and more efficient construction.

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F. Sustainability

A digital twin is used to perform environmental design testing to improve a building's performance over its entire life cycle, while reducing operating costs maintenance and so on. Building owners seeking Leadership in Energy and Environmental Design (LEED) certification can use digital twins to simulate many designs and options. By comparing different scenarios and maximizing the points earned under the LEED scoring system by comparing multiple environmental design options, obtaining LEED certification is a time-consuming task with traditional methods, but with the digital twin it allows multiple design options to be compared in a faster and more efficient way. For example, digital twins can simulate several configurations of HVAC systems and building envelopes to determine which configuration offers the highest energy efficiency [33].

G. Risk Management

A digital twin is used to enable project personnel to anticipate scenarios by integrating algorithms and data collected from smart IoT sensors to generate predictions and take necessary preventative measures in the project life cycle. Safety managers and officers can track the location of hazard areas, workers and equipment and effectively prevent injuries that may be caused by unsafe location-based behaviors. Hazardous materials can be tracked to ensure they are properly stored and monitored to send early warning signals to prevent any disasters on the job site and Digital Twins can improve employee training to deal with emergencies by reproducing hazardous situations in real life to train workers. Where employees can be prepared to handle equipment that is practically untrainable. They can run simulations in the lab to understand the risks and benefits of new procedures, and try them out to see which modifications deliver the best results.

6. Benefits of Digital Twins for AEC

After presenting the use of digital twins during the different stages of the project, we conclude that the digital twin is more than just a 3D model.

Rather, it is a collaborative approach that displays a replica of a building and displays all kinds of required information, in a virtual environment. So, it has many benefits in improving many aspects of construction projects, the most important of which are:

A. Continuous monitoring of construction progress

▪ Physical monitoring of the construction site by means of a digital twin verifies that the work performed conforms to plans and specifications.

▪ Track changes in a model generated daily and hourly and if any deviation occurs, immediate action can be taken.

▪ The condition of concrete, cracks in columns or any material displacement can be easily checked at the construction site. These discoveries lead to additional inspections and problems are caught more quickly, leading to more effective solutions.

B. Optimal use of resources

▪ Providing data related to equipment, tools and building materials in a database that can be used in future projects.

▪ Supply Chain Management and Procurement Manage time and resources and prevent workflow conflicts.

▪ Track pre-manufacturing processes to ensure they are delivered on time and identify ways to increase productivity.

▪ Better allocation of resources and avoiding wasting production time on useless operations and dealing with unnecessary materials.

▪ Avoid over-allocation of resources and dynamically forecast resource requirements on the site.

▪ Tracking the use of equipment and machinery and the use of unused ones in other jobs, which saves time and money.

C. Time and speed factor

▪ The speed of completion in project design and approval, where the collection of digital data with custom entry forms greatly reduces errors, as a result of electronic copying compared to paper forms.

▪ Project managers and their teams can reclaim time spent on routine tasks, focusing on valuable activities; Thus, significantly reducing paperwork and replacing it with a digital system.

D. Reducing construction and operating costs

▪ Optimizing cost and reducing changes during project implementation, unlike the traditional methods in which changes during implementation lead to an increase in the budget and completion time.

▪ Owners and operators can reduce costs, avoid future costs, increase occupancy rates and improve total asset value.

▪ Virtual scenarios for the construction sequence and logistics can be run and visualized, informing workers of required tasks and reducing costly re-works. Through data-driven decision-making, artificial intelligence and machine learning.

▪ Predictable maintenance activities and events that will help reduce unforeseen interventions and ultimately streamline costs throughout the operating life of the asset.

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E. Increase productivity and collaboration

▪ Vital information about the created asset can be stored and analyzed throughout its life cycle, and constantly updated. This information (such as design documents, inventories, material specifications, and schedules) can be easily accessed and used to aid decision-making and defect elimination.

▪ Enhancing coordination and cooperation between remote workers and implementing operations management by default, which enables dealing with the repercussions of crises more quickly and easily.

F. Safety and security improvement

▪ Track dangerous personnel and places on a construction site.

▪ Avoid the use of unsafe substances and activities in hazardous areas, based on real-time information.

▪ Eliminate the element of human error, reduce time spent resolving issues, troubleshooting, updating changes, re-work, etc.

▪ On-site personnel can obtain real-time information and alerts about the location, and send notification and emergency response instructions. to the worker's mobile device to prevent danger.

▪ An early notification system could be developed that would allow the construction manager to know when a field worker is in an unsafe area.

▪ Anticipate congestion on the site through the use of pedestrian simulation software, and introduce the necessary changes for the movement of site activities and individuals to avoid risks.

▪ Allow simulations to estimate the potential for damage caused by natural and man-made disasters.

G. Improving asset performance and sustainability

▪ Improve the performance of renovated buildings by simulating processes and predicting the performance of different materials.

▪ Digital Twin enables building operators to combine previously unconnected systems—from security to HVAC and road connectivity systems—to gain new insights, improve workflow, and remotely monitor operations.

▪ Monitoring and controlling water and energy consumption to achieve an environmentally friendly building.

▪ Contribute to reducing greenhouse gas emissions through monitoring and analyzing carbon emissions.

▪ Contribute to reducing transportation emissions through the application of visual communication systems for work teams instead of direct meetings.

▪ Consistently collect data from electrical and mechanical installations in buildings to be incorporated into the firefighting strategy.

H. Education and training field

▪ A digital twin is used to create simulation models based on on-site process requirements.

▪ Assists engineers in clarifying problems related to site operations, embodying those operations with utmost accuracy, and transferring them to other parties.

▪ Project parties can better explore the processes, systems, and details of the project within the virtual work environment, and the exact impact of any element on the other.

I. In future

▪ Collect and analyze data during the life of the facility to develop a database that can be transferred to future projects and provide insights into facility design criteria.

▪ Provide rich data to improve the design of future projects to make optimal use of space and meet the requirements of residents.

▪ Providing the Building Authority with access to updated building information during its life cycle allowing for intelligent planning of future projects.

▪ Use data during the lifetime of the facility to run what-if scenarios. To test different strategies for forecasting project progress and ensuring its success.

▪ Use the data collected throughout the project life cycle to develop an effective and safe demolition plan

7. Barrier of Digital Twins for AEC

Among the most important challenges facing digital twins' technology:

Standards and Regulations

Standardizing models, interfaces, protocols, and data is essential for efficient third-party communication, product and human safety, data security, and integrity, especially in industries such as aerospace, automobile, healthcare, etc [34] Besides that, standards and standards-based interoperability need to be developed to address the social and organizational challenges unfolded by digital transformation within industries [35].

A lack of device communication and data collection standards can compromise the quality of data being processed for DT, which will be reflected on its performance [36].

Sensors and Data: Loss of data during the transfer process is still an issue due to various reasons such as software incompatibilities and data fading due to external environment interferences. In addition, many types of IoT sensors collect either the same environment data or different data, while their data type may not be homogeneous, which may present many difficulties in the data analysis process.

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Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

Design Challenges: Challenges in building a digital twin model that combines product life cycle management, manufacturing execution system, and process management system. One of the biggest problems facing creating a digital twin is.

Improving the control strategy: Humans still play an important role in the current application process of the digital twin, and decision-making often depends on them based on the results obtained from researching scenarios. Therefore, it requires improving the control strategy through automatic decision-making and feedback loops, and enabling automatic control of Real time with the possibility of increasing the number of scenarios analysed to improve the efficiency and reliability of control systems.

Economic Challenges: Economic considerations and the volume of investments facing the application of digital twin technology and complementary technologies.

One of the biggest challenges DT needs to overcome to reach its full potential is the high cost associated with its implementation. The whole process of developing ultra-high-fidelity computer models and its simulation of processes to create a DT is a time-consuming and labour-intensive exercise that also requires a huge amount of computational power to run, thus making DT an expensive investment [37].

Technological challenges:

Several technologies come together to make DT a reality such as 3D simulations, IoT/IIoT, AI, big data, machine learning, and cloud computing. Since these technologies themselves are in developing phases, it impedes the evolution of DT. The infrastructure to implement DT needs to be improved to enhance the efficacy of the technology. There is a need for further research in technologies such as high-performance computing technology, machine learning technology, real-time virtual-real interactive technology, intelligent perception and connection technology, among others, in order to implement DT [38].

These include implementing real algorithms in simulation software - limited computing power even through relatively simple simulation tasks as well as incorporating big data analytics during design into the digital twin model. And when collecting real-time data directly from instruments and sensors.

▪ One of the most important challenges is the preparation of the environment, technology and trainees for the gradual transformation of the use of technology.

8. Research Importance

The scarcity of studies dealing with the application of digital twin technology in the construction sector in Syria, and therefore it covers an important research aspect.

The research deals with the technological and technical aspect of BIM and digital twin technologies, which will contribute effectively to strengthening its role and the role of BIM in Syria.

The research highlights the importance of digital twins and their benefits in the project stages of design, analysis, construction, operation, management and sustainability.

It seeks to confirm the link between the lack of awareness of digital twin technology and its spread in engineering projects in Syria.

Identifying the obstacles that prevent the application of digital twin technology in engineering projects in Syria.

Researching ways to generalize the application of digital twin technology in engineering projects in Syria.

9. Research procedures:

Research Approach:

The analytical descriptive approach was utilized in the present study. This approach was chosen as it would aid in achieving the desired objectives and generating recommendations and proposals that could potentially aid in resolving the research problem. The researcher gathered data on the influence of digital twin's technology on engineering projects. To do so, specific questions were formulated and presented in a questionnaire that was distributed to sample members. The collected data was then described and analysed.

Research community:

The research community comprises engineering sector companies, engineering offices, as well as engineering and technical education institutions within the construction sector in Syria.

The research sample:

The sample comprises partial units of society selected based on statistical rules. A random sample was chosen from the research population, and 36 responses were obtained.

Research tool:

To gather in-depth data, a questionnaire was employed as a research tool due to its objectives, methodology, and community. The questionnaire is widely used in various scientific fields as it saves time and reduces costs while allowing for data collection from a larger number of individuals than other methods. Additionally, it simplifies answering questions that require more time.

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Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

Setup steps:
The researcher began by setting the main objective of the research, which is to investigate the impact of digital twin's technology on engineering projects.
Next, the fields of measurement for the research tool were determined and divided into two sections:
Section One: Personal data, which included gender, age, educational level, years of experience, and field of work.
Section Two: 15 phrases distributed over three axes:
-The first axis estimated the level of awareness of digital twin's technology in engineering projects with 5 phrases.
- The second axis aimed to discover the importance of using digital twins technology in engineering projects with 5 phrases.
- The third axis evaluated obstacles to using digital twins technology in engineering projects with 5 phrases.
The third step involved formulating search tool phrases in their initial form according to each domain and procedural definitions measured in the questionnaire. Some phrases from previous relevant studies were also used.
The fourth step responses to the phrases were graded using a five-point Likert scale.
In the fifth step, the instructions for the research tool were formulated to introduce the purpose of the research to members of the research community. The clarity of statements and their suitability to the respondents' level were taken into account, with an emphasis on writing data for research variables.
Finally, the questionnaire was converted into an electronic form using Google and distributed to the target sample through phone applications, email, and social networking sites.

Questionnaire themes and response levels for each theme:

Table 1: Questionnaire themes and levels of response, Resource: Creations by authors (2022)

the hub	response levels				
Estimating the level of awareness of applying digital twins technology to engineering projects	at all	to a weak degree	degree Medium	to a strong degree	To a very strong degree
Discover the importance of using digital twins technology	not important	of little importance	Of moderate importance	Important	very important
Evaluation of barriers to using digital twins technology	Very weak	weak	middle	strong	Very strong
the scale	1	2	3	4	5

Sample demographics:
Gender:

Table 2: The percentage breakdown of the participants' sex, Source: Creations by authors (2022)

1. What is it your gender?	
Male	40%
Feminine	60%

The sample population was composed of 40% males and 60% females, with the majority of respondents being female.

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The age:

Table 3: Percentage of the age groups of the research sample, Resource: Creations by authors (2022)

2. how much Your age?	
less than 25	29%
From 25 to 35	55%
From 35 to 49	16%

It is evident that the majority of the respondents fall within the age bracket of 25 to 35 years, accounting for approximately 55% of the overall sample size. Individuals below the age of 25 represent 29% of the respondents, while those aged between 35 and 49 make up 16% of the total sample, indicating that a significant portion of the participants are categorized as youth.

Educational level:

Table 4: Percentage of the educational level of the research sample, Resource: Creations by authors (2022)

3. What is the educational level?	
Secondary	8%
Average Institute	10%
University	63%
Postgraduate	19%

Regarding education level, the majority of respondents held university degrees, making up 63% of the sample. 19% had postgraduate certificates, 10% held intermediate institute certificates, and 8% had secondary certificates. These findings suggest that the majority of participants were from an educated background.

Years of Experience:

Table 5: Percentage of years of experience for the research sample, Resource: Creations by authors (2022)

4. What is a number Years of Experience?	
From 1 to 3 years	55%
From 4 to 6 years	21%
From 7 to 10 years	6%
More than 10 years	18%

Upon examining the study's participants, it was discovered that the highest percentage, constituting approximately half of the sample, had between one and three years of experience. The next largest group, accounting for 21%, possessed four to six years of experience, while 18% had over ten years of experience. Finally, the smallest category consisted of those with seven to ten years of experience, making up just 6% of the total sample.

Employment:

Table 6: Percentage of the field of work of the research sample, Resource: Creations by authors (2022)

3. Who the Employment?	
Construction contracting	39%
Engineering consultances	44%
Engineering and technical education	17%

The study's findings showed that the participants were divided into three categories: 44% were from engineering consulting offices, 39% were in the construction contracting industry, and 17% were in education and technology.

8. Analysis and research

Questionnaires were used in the research area to investigate the significance of implementing digital twin technology and its barriers in engineering projects in Syria.

The first axis: Estimating the level of awareness of applying digital twin's technology to engineering projects.
The first axis included five items to measure the level of awareness of the participants in the questionnaire.
From the results, it is clear that the degree of knowledge of the concept of digital twins in general is medium, and perhaps the reason is due to the fact that digital twins are of new origin and use in the fields of work in general. The general weighted average of the first axis indicates a weak degree of knowledge and awareness of the digital twin and the way it is used and applied in the engineering field.

DOI: https://doi.org/10.54216/IJBES.080201
Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

The second axis: discovering the importance of using digital twin's technology in engineering projects.
The second axis of the questionnaire aimed to measure the significance of implementing digital twin technology among the participants. Results revealed that digital twins play a crucial role in the design phase, as they aid in minimizing obstacles and streamlining construction work in subsequent stages. The importance of digital twins is also evident in the maintenance and facility management phase due to their preservation benefits. Similarly, the implementation and handover phases benefit from digital twins' quality design phase, leading to fewer obstacles. Although the importance of digital twins in the demolition phase may have decreased due to sufficient information on the building's nature and characteristics, the overall weighted average of the second axis highlights the immense importance of digital twins in all stages of engineering projects' life cycle and their application in the engineering field.
The third axis: assessing the obstacles to using digital twin's technology on engineering projects.
The axis comprised of five items that aimed to gauge the obstacles faced by participants in adopting this technology. The findings revealed that the primary obstacle was the lack of knowledge about digital twins technology, which corroborated the first axis of the research. Despite being mandatory, other barriers such as insufficient training, qualifications, and resources have decreased due to state and university efforts to modernize education and keep up with scientific advancements. Plans for training and education in this field are being developed to ensure that necessary requirements are met.

10. Results and Recommendations:

10.1 Results:
1- The digital twin technology has been found to cause a significant transformation in engineering projects across all stages of the facility, from planning and design to analysis, implementation, operation, data management, maintenance, building management, and even demolition. This technology offers numerous advantages such as faster and more efficient project operations, easy sharing of information with project parties, improved design efficiency through the use of building analysis technology, rapid simulation and performance expectations before and during the operation cycle which helps in making innovative solutions and improvements. Additionally, it reduces costs while raising the quality and productivity of the project. This results in better customer service by providing them with a better understanding of the project as well as support information over the life of the building.
2- The research findings indicate a low level of awareness and knowledge regarding digital twin technology in engineering projects. This lack of awareness is due to several reasons including failure to keep up with new studies and research as well as a lack of interest in this sector which is a result of the crisis that passed through the country in the previous stage and the blockade that followed it.
3- The research highlighted the significance of infrastructure development and staying up-to-date with technical advancements to overcome the challenges hindering the use of modern technologies in the construction industry. This will enhance service quality and improve urban conditions.
4- Real-time visual management through digital twin technology was found to be crucial for project personnel to comprehend the detailed status of the entire facility. High-density data streams are continuously processed and analysed in real-time through a centralized control platform, which is more efficient than traditional manual work.
5- Artificial intelligence and data analysis skills were identified as essential in engineering projects. They play a vital role in diagnosing, evaluating, and treating building conditions in collaboration with virtual reality techniques and visual management.
6- The research revealed that insufficient expertise and trained personnel are among the primary challenges facing digital twin implementation.

10.2 Recommendations:

1. It is crucial to focus on training and qualifying workers in the field of digital twin technology for building. This should be included in engineering institutes and colleges' training courses, with qualified courses and trainers provided. Cooperation with qualified companies to offer necessary support is also essential. Specialized and accredited training courses should be prioritized.
2. Unions should play an active role in raising awareness and promoting digital twin technology within the engineering community. Workshops should be held to increase awareness of its importance and provide training opportunities. Events and seminars that involve all construction sector workers, stakeholders, and real estate agents are also recommended.
3. Companies and institutions in the construction sector should be prepared and encouraged to undergo digital transformation for engineering projects gradually. This includes completing all necessary preparations for implementation, such as training, technical support, programs, and worker qualification to accept the transition to actual application. Initially, it should be applied to a limited number of projects before moving on to higher levels of projects.

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4. To support digitization projects, the government should adopt BIM and digital twin technologies, establish binding rules for their use in major special projects, obtain necessary approvals and licenses from relevant agencies, prepare appropriate specifications, codes, and contracts, and gradually transition to generalize their use in other projects.
5. The government should also provide the necessary resources and improve infrastructure to keep up with technological advancements required for implementing digital twin technology such as artificial intelligence, 5G networks, robotics, etc., to create an auxiliary infrastructure for digital twin implementation.
6. Additionally, the government should support more studies related to digital twin technology across all areas of the construction sector including design, operation and maintenance. It is important to emphasize their significance and compare similar studies to raise the level of engineering work.
7. It is important to address the obstacles and challenges that may arise during the implementation of digital twin technology in engineering projects. This includes issues related to data privacy and security, interoperability between different software systems, and the need for standardized protocols and procedures. A comprehensive risk management plan should be developed to mitigate these challenges.
8. The benefits of digital twin technology should be communicated effectively to all stakeholders involved in engineering projects. This includes highlighting its potential to improve project efficiency, reduce costs, enhance safety, and enable better decision-making through data analytics.
9. Continuous monitoring and evaluation of digital twin technology implementation should be conducted to ensure its effectiveness in improving engineering project outcomes. Feedback from workers, clients, and other stakeholders should be solicited regularly to identify areas for improvement and make necessary adjustments.
10. Finally, it is important to stay up-to-date with the latest developments in digital twin technology and its applications in engineering projects. This can be achieved through participation in conferences, workshops, and training programs focused on this topic.

Funding: “This research received no external funding”

Conflicts of Interest: “The authors declare no conflict of interest.”

References

[1] Vanlande, R., C. Nicolle and C. Cruz (2008). "IFC and building lifecycle management." Automation in Construction 18(1): 70-78.
[2] Hooper, M. and A. Ekholm (2010). A pilot research: Towards BIM integration-An analysis of design information exchange & coordination. Proceedings of the CIB W.
[3] Das, M., J. C. P. Cheng and S. S. Kumar (2015). "Social BIMCloud: a distributed cloud-based BIM platform for object-based lifecycle information exchange." Visualization in Engineering 3(1): 8.
[4] Tang, S., D. R. Shelden, C. M. Eastman, P. Pishdad-Bozorgi and X. Gao (2020). "BIM assisted Building Automation System information exchange using BACnet and IFC." Automation in Construction 110: 103049.
[5] Shafto, M., M. Conroy, R. Doyle, E. Glaessgen, C. Kemp, J. LeMoigne and L. Wang (2010). "Draft modeling,simulation, information technology & processing roadmap." Technology Area 11
[6] Negri, E., L. Fumagalli and M. Macchi (2017). "A Review of the Roles of Digital Twin in CPS-based Production Systems." Procedia Manufacturing 11: 939-948.
[7] Zhuang, C., J. Liu and H. Xiong (2018). "Digital Twin-based smart production management and control framework for the complex product assembly shop-floor." Int J Adv Manuf Technol 96: 1149.
[8] Machado, F. A., R. C. J. P. R. i. A. Ruschel and B. Construction (2018). "Solutions integrating BIM and Internet Of Things in building life cycle: a critical review." 9(3): 204-222.
[9] Tang, S., D. R. Shelden, C. M. Eastman, P. Pishdad-Bozorgi and X. Gao (2019). "A review of building information modeling (BIM) and the internet of things (IoT) devices integration: Present status and future trends."Automation in Construction 101: 127-139
[10] Shahinmoghadam, M. and A. Motamedi (2019). Review of BIM-centred IoT Deployment–State of the Art, Opportunities, and Challenges. Proceedings of the 36th International Symposium on Automation and Robotics in Construction (ISARC 2019).
[11] Elhendawi, A., Smith, A. & Elbeltagi, E., 2019. Methodology for BIM implementation in the Kingdom of Saudi Arabia. International Journal of BIM and Engineering Science, 2(1), pp. 1-21
[12] Shaban, M. & Elhendawi, A., 2018. Building Information Modeling in Syria: Obstacles and Requirements for Implementation. International Journal of BIM and Engineering Science, 1(1), pp. 42-64.
[13] Evans, M., Farrell, P., Elbeltagi, E., Mashali, A. and Elhendawi, A., 2020. Influence of partnering agreements associated with BIM adoption on stakeholder's behaviour in construction mega-projects. International Journal of BIM and Engineering Science, 3(1), pp.1-20.

DOI: https://doi.org/10.54216/IJBES.080201
Received: October 12, 2023 Revised: January 11, 2024 Accepted: May 08, 2024

[14] Banawi, A., Aljobaly, O. & Ahiable, C., 2019. A Comparative Review of Building Information Modeling Frameworks. International Journal of BIM and Engineering Science, 2(2), pp. 23-49.
[15] Elhendawi, A., Smith, A. & Elbeltagi, E., 2019. Methodology for BIM implementation in the Kingdom of Saudi Arabia. International Journal of BIM and Engineering Science, 2(1), pp. 1-21.
[16] S Ahmed, P Dlask (2018).The Gradual Transition to BIM in Syrian companies
[17] Yusof, N., Ishak, S. & Doheim, R., 2018. An Exploratory Study of Building Information Modelling Maturity in the Construction Industry. International Journal of BIM and Engineering Science, 1(1), pp. 6-19.
[18] Elhendawi, A., 2018. Methodology for BIM Implementation in KSA in AEC Industry. Master of Science MSc in Construction Project Management ed. Edinburgh, UK: Edinburgh Napier University, UK.
[19] Al Hammoud, E., 2021. Comparing BIM Adoption Around The World, Syria's Current Status and Furture. International Journal of BIM and Engineering Science, 4(2), pp. 64-78
[20] . Safour, R., Ahmed, S. & Zaarour, B., 2021. BIM Adoption around the World. International Journal of BIM and Engineering Science, 4(2), pp. 49-63.
[21] Grieves, M. Origins of the Digital Twin Concept. 2016: https://www.researchgate.net/publication/307509727_Origins_of_the_Digital_Twin_Concept.
[22] Grieves, M.W. Product lifecycle management: The new paradigm for enterprises. Int. J. Prod. Dev. 2005, 2, 71–84.
[23] Gelernter, D. Mirror Worlds: Or: The Day Software Puts the Universe in a Shoebox. How it Will Happen and What it Will Mean; OxfordUniversity Press: Oxford, UK, 1993.
[24] Shafto, M.; Conroy, M.; Doyle, R.; Glaessgen, E.; Kemp, C.; LeMoigne, J.; Wang, L. Draft modeling, simulation, information technology & processing roadmap. Technol. Area 2010
[25] Grieves, M, Excerpt from Forthcoming Chapter Intelligent Digital Twins and the Development and Management of Complex Systems Digital Twin Institute, Cocoa Beach, 2021.
[26] Y. Schwartz, S. Eleftheriadis, R. Raslan, and D. Mumovis, "Semantically enriched BIM life cycle assessment to enhance buildings" environmental performance, in Proceedings of the CIBSE Technical Symposium, Edinburgh, UK, 2016.
[27] D. Greenbaum, A. Lavazza, K. Beier, K. Bruynseels, F. Santoni De Sio, and J. Van Den Hoven, "Digital Twins in Health Care: Ethical Implications of an Emerging Engineering Paradigm", Front. Genet. |www.frontiersin.org, vol. 9, p. 31, 2018, doi: 10.3389/fgene.2018.00031
[28] FM system, Manage Your Facilities & Real Estate More Effectively, Available at: https://fmsystems.com/our-software/, (2016)
[29] Surjya Kanta Pal, Debasish Mishra, Arpan Pal, Samik Dutta, 2021, "Digital Twin – Fundamental Concepts to Applications in Advanced Manufacturing", SpringerLink, Springer Nature Switzerland AG, 2021, ISBN 978-3-030-815-9.
[30] Knapp, G. L., T. Mukherjee, J. S. Zuback, H. L. Wei, T. A. Palmer, A. De,and T. DebRoy. 2017, "Building blocks for a digital twin of additive manufacturing", Acta Mater. 135 (Aug): 390–399. https://doi.org/10.1016/j.actamat.2017.06.039.
[31] Oliver, D., D. Adam, and A. P. Hudson-Smith. 2018, "Living with a digital twin: Operational management and engagement using IoT and mixed realities at UCL's Here East Campus on the Queen Elizabeth Olympic Park", In Proc., GIScience and Remote Sensing. Leicester, UK: Geographical Information Science Research UK.
[32] Shyam Varan Nath, Pieter van Schalkwyk, 2021, "Building Industrial Digital Twins", 2021, Published by Packt Publishing Ltd, Birmingham, UK, ISBN 978-1-83921-907-8.

[33] M. Batty, 2018, "Digital twins", Environment and Planning B: Urban Analytics and City Science 45 (2018) 817–820, https://doi.org/10.1177/2399808318796416.
[34] Singh, S.; Shehab, E.; Higgins, N.; Fowler, K.; Tomiyama, T.; Fowler, C. Challenges of Digital Twin in High. Value Manufacturing; 0148-7191; SAE Technical Paper; SAE International: Warrendale, PA, USA, 2018.
[35] Wyckoff, A.; Pilat, D. Key Issues for Digital Transformation in the G20; OECD: Berlin, Germany, 2017.
[36] Common Pitfalls to Digital Twin Implementation. https://www.compunneldigital.com/infographic/commonpitfalls-to-digital-twin-zmplementation/#gref
[37] Gabor, T.; Belzner, L.; Kiermeier, M.; Beck, M.T.; Neitz, A. A simulation-based architecture for smart cyber-physical systems. In Proceedings of the 2016 IEEE International Conference on Autonomic Computing (ICAC), Wuerzburg, Germany, 17–22 July 2016; pp. 374–379
[38] Tao, F.; Cheng, J.; Qi, Q.; Zhang, M.; Zhang, H.; Sui, F. Digital twin-driven product design, manufacturing and service with big data. Int. J. Adv. Manuf. Technol. 2018, 94, 3563–3576.

DOI: https://doi.org/10.54216/IJBES.080201
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