

JOURNAL OF POLICIES AND RECOMMENDATIONS

Volume: 5 Issue: 3

(July-September), 2026

ISSN: 2957-4129





Research Article

Exploring Digital Twin Integration in Sustainable Interior Design Practices: A Qualitative Study of Design Professionals

Mofijul Islam¹; Kazi Abdul Mannan²

¹ Department of Graphic Design & Multimedia, ²Department of Business Administration, Shanto-Mariam University of Creative Technology
Uttara, Dhaka-1230, Bangladesh.

Corresponding Author Mofijul Islam, Email: mdmofijul156@gmail.com

ARTICLE INFO

Keywords:
digital twin,
sustainable interior
design, smart
environments,
lifecycle
assessment, iot
integration, design
innovation,
qualitative research

ABSTRACT

The integration of advanced digital technologies has significantly transformed sustainable design practices in the built environment, with Digital Twin (DT) technology emerging as a key innovation. This study explores the application of Digital Twin systems in sustainable interior design through a qualitative analysis of secondary data, including academic literature, industry reports, and case studies. Grounded in socio-technical systems theory and diffusion of innovation theory, the research examines how design professionals perceive, adopt, and implement DT technologies to enhance sustainability outcomes. The findings indicate that Digital Twins facilitate improved design decision-making, real-time environmental monitoring, lifecycle material optimisation, and user-centric adaptive environments. These capabilities contribute to enhanced energy efficiency, reduced environmental impact, and improved occupant well-being. However, challenges such as high implementation costs, technical complexity, data interoperability issues, and resistance to change hinder widespread adoption. The study highlights the need for capacity building, standardisation, and policy support to promote effective DT integration. By providing a comprehensive synthesis of current knowledge, this research contributes to the growing discourse on digital transformation and sustainability in interior design practices..

Received: 20 May 2026 / Revised: 25 June 2026 / Accepted: 30 June 2026 / Published: 3 July 2026

Copyright: © 2026 by the authors. Licensee KMF Publishers (www.kmf-publishers.com). This open-access article is distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

DOI: <https://doi.org/10.64907/xkmf.v5i3.iopr.4>

1. Introduction

The accelerating pace of environmental degradation, coupled with rapid urbanisation and resource scarcity, has intensified the global demand for sustainable design practices across all sectors of the built environment. Interior design, once primarily concerned with aesthetics, functionality, and user comfort, is increasingly recognised as a critical domain for advancing sustainability goals. Contemporary interior design practices must now address complex environmental challenges, including energy consumption, material efficiency, indoor environmental quality, and lifecycle impacts (Kang & Guerin, 2009). Within this evolving landscape, digital technologies have emerged as transformative enablers of sustainable innovation.

Among these technologies, Digital Twin (DT) systems represent a significant paradigm shift in how built environments are conceptualised, designed, and managed. A Digital Twin is commonly defined as a dynamic, virtual representation of a physical system that is continuously updated through real-time data integration, simulation, and feedback mechanisms (Fuller et al., 2020). Unlike traditional modelling tools, DTs enable continuous interaction between the physical and digital realms, thereby facilitating predictive analysis, performance optimisation, and informed decision-making across the lifecycle of a space.

In the broader architecture, engineering, and construction (AEC) industry, Digital Twin technology has gained increasing attention

for its capacity to enhance building performance, reduce operational costs, and support sustainable resource management (Bolton et al., 2018). When integrated with Building Information Modelling (BIM), Internet of Things (IoT) devices, and advanced analytics, DTs create a comprehensive digital ecosystem capable of monitoring and optimising building systems in real time (Lu et al., 2020). However, while significant research has explored DT applications at the building and infrastructure levels, comparatively little attention has been paid to their role in interior design practices, where many critical sustainability decisions are made.

Interior spaces are central to human experience and account for a substantial portion of energy use, material consumption, and environmental impact. Decisions related to lighting design, HVAC integration, furniture selection, and material finishes can significantly influence both environmental performance and occupant well-being. Digital Twin technology offers interior designers the ability to simulate and evaluate these decisions before implementation, thereby reducing waste, improving efficiency, and enhancing user outcomes. For instance, designers can use DTs to model daylight penetration, optimise thermal comfort, or assess the environmental impact of different material choices throughout their lifecycle.

Despite these promising capabilities, the adoption of Digital Twin technology in interior design remains uneven and faces several barriers. These include high implementation costs, limited technical

expertise among design professionals, lack of standardised frameworks, and challenges related to data interoperability (Pärn et al., 2017; Lu et al., 2020). Furthermore, the integration of DTs requires a shift in professional practice, moving from static design processes to dynamic, data-driven workflows. This transformation raises important questions about how design professionals perceive and engage with these technologies.

In addition to technical and organisational challenges, there is also a need to critically examine the socio-cultural implications of Digital Twin integration in design practice. As socio-technical systems, DTs do not operate in isolation but are embedded within networks of human actors, institutional structures, and cultural norms (Trist, 1981). Understanding how designers interpret, adopt, and adapt DT technologies is therefore essential for evaluating their effectiveness and long-term sustainability impact.

This study seeks to address these gaps by exploring the integration of Digital Twin technology in sustainable interior design practices through a qualitative analysis of secondary data. Specifically, the research aims to: examine how Digital Twin technologies are conceptualised and utilised in interior design; identify the perceived benefits and challenges associated with their adoption; and analyse the implications of DT integration for sustainable design outcomes.

By synthesising insights from academic literature, industry reports, and case studies, this research contributes to the growing body of knowledge on digital transformation in the built environment. It also provides practical

insights for design professionals, educators, and policymakers seeking to leverage Digital Twin technology to advance sustainability in interior design. Ultimately, the study underscores the importance of integrating technological innovation with human-centred design principles to create more sustainable, resilient, and adaptive interior environments.

2. Literature Review

Digital Twin technology has its origins in the manufacturing and aerospace sectors, where it was initially used to simulate and monitor complex systems. The concept gained prominence through its application in product lifecycle management, enabling real-time feedback between physical assets and their digital counterparts (Fuller et al., 2020). Over time, advancements in sensor technologies, cloud computing, and data analytics have facilitated the expansion of DT applications into the built environment.

In the context of architecture and construction, Digital Twins have evolved from static digital models to dynamic systems capable of real-time interaction and predictive analysis. Bolton et al. (2018) highlight the importance of the “Gemini Principles,” which emphasise purpose, trust, and function in the development of national-scale digital twins. These principles underscore the need for interoperability, data security, and user-centric design in DT implementation.

2.1 Integration with Building Information Modelling (BIM)

Building Information Modelling (BIM) serves as a foundational technology for Digital Twin systems. BIM provides detailed geometric and semantic information about building components, which can be integrated with real-time data to create dynamic DT models (Pärn et al., 2017). While BIM primarily supports the design and construction phases, Digital Twins extend their functionality into the operational phase by enabling continuous monitoring and optimisation.

Lu et al. (2020) argue that the transition from BIM to DT represents a shift from static information management to dynamic asset management. This integration allows for enhanced decision-making, particularly in areas such as energy efficiency, maintenance planning, and occupant comfort. However, challenges related to data standardisation and system compatibility remain significant barriers.

2.2 Sustainable Interior Design Principles

Sustainable interior design is grounded in the principles of environmental responsibility, resource efficiency, and human well-being. Key considerations include the use of eco-friendly materials, energy-efficient systems, and designs that promote health and productivity (Kang & Guerin, 2009). Lifecycle thinking is also central to sustainable design, emphasising the environmental impact of materials and systems from production to disposal.

Traditional tools used in sustainable interior design, such as energy modelling software and lifecycle assessment tools, often operate in isolation and provide limited real-time feedback. This limitation restricts the ability of designers to make informed decisions throughout the design process. Digital Twin technology addresses this gap by enabling continuous simulation and evaluation.

2.3 Digital Twin Applications in Interior Design

Although research specifically focused on interior design is limited, existing studies suggest several potential applications of Digital Twin technology in this domain. These include:

- **Energy Optimisation:** DTs can simulate lighting, HVAC systems, and occupancy patterns to optimise energy use.
- **Material Lifecycle Analysis:** Designers can evaluate the environmental impact of materials over time.
- **Indoor Environmental Quality (IEQ):** Real-time monitoring of air quality, temperature, and lighting conditions enhances occupant comfort.
- **Space Utilisation:** DTs enable analysis of spatial efficiency and user behaviour.

According to Lu et al. (2020), these applications contribute to more sustainable and adaptive interior environments.

2.4 Role of IoT and Smart Technologies

The integration of Internet of Things (IoT) devices is critical for the functionality of Digital Twins. Sensors embedded within interior spaces collect data on environmental conditions, occupancy, and system performance. This data is transmitted to the DT model, enabling real-time updates and analysis (Fuller et al., 2020).

Smart technologies, including artificial intelligence (AI) and machine learning, further enhance DT capabilities by enabling predictive analytics and automated decision-making. For example, AI algorithms can analyse occupancy patterns to optimise lighting and HVAC systems, reducing energy consumption.

2.5 Benefits of Digital Twin Integration

The literature identifies several benefits of DT integration in sustainable design:

- **Improved Decision-Making:** Real-time data and simulation capabilities support informed design choices.
- **Enhanced Sustainability:** DTs enable efficient resource use and reduce environmental impact.
- **Cost Savings:** Predictive maintenance reduces operational costs.
- **User-Centric Design:** Continuous feedback improves occupant experience.

These benefits align with broader sustainability goals and support the transition

toward smart and resilient built environments (Bolton et al., 2018).

2.6 Challenges and Barriers

Despite its advantages, DT adoption faces several challenges:

- **Technical Complexity:** Integration of multiple systems requires advanced expertise.
- **High Costs:** Implementation and maintenance can be expensive.
- **Data Interoperability:** Lack of standardised formats hinders integration.
- **Resistance to Change:** Professionals may be reluctant to adopt new technologies.

Pärn et al. (2017) emphasise that overcoming these barriers requires organisational change, training, and the development of industry standards.

2.7 Theoretical Perspectives on Technology Adoption

The adoption of Digital Twin technology can be understood through the lens of Diffusion of Innovation Theory (Rogers, 2003). Key factors influencing adoption include perceived benefits, compatibility with existing practices, and ease of use.

Socio-Technical Systems Theory (Trist, 1981) further highlights the importance of aligning technological and social elements. Successful DT integration depends not only on technical capabilities but also on organisational culture, professional skills, and stakeholder collaboration.

2.8 Research Gap

While the literature provides valuable insights into Digital Twin technology and sustainable design, several gaps remain. First, there is limited research focusing specifically on interior design practices. Second, most studies adopt a technical perspective, with insufficient attention to the experiences and perceptions of design professionals. Third, there is a lack of qualitative research exploring the socio-technical dimensions of DT adoption.

This study addresses these gaps by providing a qualitative analysis of secondary data, focusing on the perspectives of design professionals and the implications of Digital Twin integration for sustainable interior design.

3. Theoretical Framework

The integration of Digital Twin (DT) technology into sustainable interior design practices requires a robust theoretical foundation that captures both technological innovation and human interaction within design environments. This study adopts an interdisciplinary theoretical framework drawing primarily on Socio-Technical Systems (STS) Theory and Diffusion of Innovation (DOI) Theory, complemented by insights from Sustainability Transition Theory. Together, these frameworks provide a comprehensive lens for analysing how Digital Twin technologies are conceptualised, adopted, and operationalised in professional interior design contexts.

3.1 Socio-Technical Systems Theory

Socio-Technical Systems (STS) Theory, originally developed by Trist (1981), emphasises the interdependence between social and technical components within organisational systems. According to this perspective, technological innovations cannot be effectively implemented without considering the human, organisational, and cultural contexts in which they operate. In the case of Digital Twin integration, STS theory highlights the need to examine how design professionals interact with DT technologies, how workflows are restructured, and how institutional norms shape adoption processes.

Interior design practice is inherently socio-technical, involving collaboration among designers, clients, engineers, and other stakeholders. The introduction of Digital Twin technology transforms these interactions by enabling real-time data sharing, simulation, and collaborative decision-making. However, this transformation also introduces complexity, requiring new skill sets, changes in professional roles, and adjustments to organisational processes (Pärn et al., 2017).

From an STS perspective, successful DT integration depends on achieving a balance between technical efficiency and social usability. For instance, while DT systems may offer advanced simulation capabilities, their effectiveness is contingent upon designers' ability to interpret and apply the generated data. This underscores the importance of user-centred design in the development of DT platforms, ensuring that they align with the cognitive and practical needs of design professionals.

Furthermore, STS theory draws attention to issues of power, control, and knowledge distribution within digital environments. The adoption of DT technologies may shift decision-making authority toward data-driven processes, potentially challenging traditional design practices. Understanding these dynamics is crucial for assessing the broader implications of DT integration in sustainable interior design.

3.2 Diffusion of Innovation Theory

Diffusion of Innovation (DOI) Theory, proposed by Rogers (2003), provides a valuable framework for understanding how new technologies are adopted within professional communities. According to this theory, the adoption of an innovation is influenced by five key attributes: relative advantage, compatibility, complexity, trialability, and observability.

In the context of Digital Twin technology, relative advantage refers to the perceived benefits of DTs over traditional design tools, such as enhanced simulation capabilities and real-time performance monitoring. Compatibility relates to how well DT systems align with existing design practices and workflows. Complexity addresses the perceived difficulty of using DT technologies, which can be a significant barrier to adoption. Trialability and observability refer to the extent to which DT technologies can be tested and their benefits demonstrated in practice.

DOI theory is particularly relevant for analysing the adoption behaviour of interior design professionals, who may vary in their willingness to embrace new technologies.

Early adopters are likely to experiment with DT systems and integrate them into their workflows, while others may resist due to perceived risks or lack of familiarity (Rogers, 2003).

The theory also highlights the role of communication channels and social networks in facilitating technology adoption. Professional associations, design firms, and educational institutions play a critical role in disseminating knowledge about DT technologies and shaping attitudes toward their use. This underscores the importance of training programs, workshops, and case studies in promoting DT adoption.

3.3 Sustainability Transition Theory

To complement the STS and DOI frameworks, this study incorporates insights from Sustainability Transition Theory, which examines how socio-technical systems evolve toward more sustainable configurations (Geels, 2002). This perspective is particularly relevant for understanding the broader implications of Digital Twin integration in sustainable interior design.

Sustainability transitions involve shifts in technologies, practices, and institutional structures that collectively contribute to environmental goals. Digital Twin technology can be viewed as a “niche innovation” that has the potential to disrupt existing design practices and promote more sustainable outcomes. However, its impact depends on interactions with broader “regime” structures, including industry standards, regulatory frameworks, and market dynamics.

From this perspective, the integration of DTs in interior design is not merely a technical change but part of a broader transformation toward data-driven, sustainable design practices. This transformation requires alignment between technological innovation, professional practices, and policy frameworks.

3.4 Integrated Theoretical Model

By combining STS, DOI, and Sustainability Transition Theory, this study develops an integrated framework for analysing Digital Twin adoption in sustainable interior design. STS theory provides insights into the interaction between human and technological systems, DOI theory explains adoption behaviour, and Sustainability Transition Theory situates DT integration within broader systemic change.

This integrated approach allows for a nuanced understanding of both the micro-level experiences of design professionals and the macro-level dynamics shaping the evolution of sustainable design practices.

4. Methodology

This study adopts a qualitative research design to explore the integration of Digital Twin technology in sustainable interior design practices. Qualitative research is particularly well-suited for investigating complex, context-dependent phenomena, as it enables in-depth analysis of meanings, perceptions, and experiences (Creswell & Poth, 2018). Given the exploratory nature of this study and the limited availability of empirical data on DT use in interior design, a qualitative approach provides the flexibility

needed to synthesise diverse sources of information.

The research is based on secondary data analysis, which involves the systematic examination of existing data sources, including academic literature, industry reports, and case studies. This approach enables the researcher to draw on a wide range of perspectives and identify patterns across different contexts.

4.1 Data Sources and Selection Criteria

Data for this study were collected from multiple sources to ensure comprehensiveness and reliability. These include:

- Peer-reviewed journal articles from databases such as Scopus, Web of Science, and Google Scholar
- Industry reports from organisations involved in digital construction and smart building technologies
- Case studies documenting the application of Digital Twin technology in design and construction projects
- Professional publications and white papers

The selection of sources was guided by the following criteria:

- Relevance to Digital Twin technology and/or sustainable design
- Focus on the built environment, particularly interior or architectural design
- Publication in reputable academic or industry outlets

- Recency, with preference given to studies published within the last decade

4.2 Data Analysis Method

The study employs thematic analysis, a widely used qualitative method for identifying, analysing, and interpreting patterns within data (Braun & Clarke, 2006). The analysis followed a six-phase process:

- **Familiarisation:** The researcher reviewed all selected sources to gain an overall understanding of the content.
- **Initial Coding:** Relevant segments of text were coded based on key concepts such as DT applications, sustainability benefits, and adoption challenges.
- **Theme Development:** Codes were grouped into broader themes reflecting recurring patterns across the data.
- **Review of Themes:** Themes were refined to ensure coherence and consistency.
- **Definition and Naming:** Each theme was clearly defined and labelled.
- **Interpretation:** Themes were interpreted in relation to the research objectives and theoretical framework.

This systematic approach ensures transparency and rigour in the analysis process.

4.3 Trustworthiness and Validity

To enhance the credibility and reliability of the study, several strategies were employed:

- **Triangulation:** Data were collected from multiple sources to ensure a comprehensive understanding of the topic.
- **Peer-reviewed sources:** Preference was given to high-quality academic publications.
- **Transparent methodology:** The research process was clearly documented to allow for replication.
- **Theoretical grounding:** The use of established theories strengthens the interpretive framework.

These measures align with qualitative research standards for trustworthiness, including credibility, transferability, dependability, and confirmability (Creswell & Poth, 2018).

4.4 Ethical Considerations

As this study relies exclusively on secondary data, it does not involve direct interaction with human participants. Therefore, issues related to informed consent and confidentiality are not applicable. However, ethical considerations were addressed by:

- Properly citing all sources in accordance with APA guidelines
- Avoiding plagiarism and ensuring accurate representation of original authors' ideas
- Critically evaluating sources to avoid bias or misinterpretation (Mannan & Farhana, 2026)

4.5 Limitations of the Study

Despite its strengths, the study has several limitations. First, the reliance on secondary data may limit the depth of insights into the

lived experiences of design professionals. Second, the findings are dependent on the availability and quality of existing literature, which may not fully capture emerging practices. Third, the lack of primary data collection means that the study cannot provide empirical validation of its findings.

However, these limitations are mitigated by the breadth of sources analysed and the use of a rigorous analytical framework. Future research could build on this study by conducting primary data collection, such as interviews or surveys with design professionals.

5. Findings and Analysis

The thematic analysis of secondary data reveals that the integration of Digital Twin (DT) technology in sustainable interior design practices is characterised by a set of interrelated benefits, applications, and challenges. These findings are organised into six major themes: enhanced design decision-making, real-time performance monitoring, lifecycle assessment and material optimisation, improved interdisciplinary collaboration, user-centric and adaptive environments, and barriers to implementation.

5.1 Enhanced Design Decision-Making

One of the most significant contributions of Digital Twin technology to interior design is its ability to support evidence-based decision-making. Traditional design processes often rely on static models and assumptions, limiting the ability to anticipate performance outcomes. In contrast, DT

systems enable designers to simulate multiple scenarios, analyse potential impacts, and make informed choices before implementation (Fuller et al., 2020).

For instance, designers can evaluate different lighting configurations to optimise natural daylight usage and reduce reliance on artificial lighting. Similarly, thermal simulations can inform the selection of materials and spatial arrangements that enhance energy efficiency. This capability aligns with the principles of sustainable design, which emphasise minimising environmental impact while maximising functionality and comfort (Kang & Guerin, 2009).

Moreover, the integration of DTs with advanced analytics allows for predictive modelling, enabling designers to anticipate future performance under varying conditions. This predictive capacity represents a shift from reactive to proactive design strategies, as highlighted by Lu et al. (2020). The ability to foresee potential issues and optimise solutions during the design phase significantly reduces the likelihood of costly modifications during construction or operation.

5.2 Real-Time Performance Monitoring

Another key theme is the role of Digital Twins in enabling real-time monitoring of interior environments. By integrating IoT sensors, DT systems continuously collect data on variables such as temperature, humidity, air quality, and occupancy patterns. This data is fed into the digital model,

providing a dynamic representation of the physical space (Fuller et al., 2020).

This real-time feedback loop allows designers and facility managers to monitor performance and make adjustments as needed. For example, HVAC systems can be optimised based on occupancy data, reducing energy consumption while maintaining comfort. Similarly, lighting systems can be adjusted in response to natural light availability, further enhancing energy efficiency.

The implications of real-time monitoring extend beyond energy savings. Improved indoor environmental quality (IEQ) has been linked to enhanced occupant well-being, productivity, and health outcomes. By providing continuous insights into environmental conditions, DT systems enable designers to create healthier and more responsive interior spaces.

5.3 Lifecycle Assessment and Material Optimisation

Lifecycle thinking is a cornerstone of sustainable design, and Digital Twin technology plays a critical role in facilitating comprehensive lifecycle assessment (LCA). DT systems enable designers to track materials from production to disposal, providing insights into their environmental impact over time.

Through simulation and data analysis, designers can compare different materials based on factors such as carbon footprint, durability, and recyclability. This information supports more sustainable material selection and reduces waste (Lu et al., 2020). Additionally, DTs can be used to monitor the

performance of materials over time, identifying opportunities for maintenance, reuse, or replacement.

The ability to integrate LCA into the design process represents a significant advancement over traditional methods, which often rely on static data and assumptions. By providing real-time and predictive insights, DT systems enable a more holistic approach to sustainability.

5.4 Improved Interdisciplinary Collaboration

Interior design is inherently collaborative, involving multiple stakeholders with diverse expertise. Digital Twin technology facilitates collaboration by providing a shared digital platform where stakeholders can access and interact with the same data and models.

This shared environment enhances communication and coordination, reducing misunderstandings and improving project outcomes (Bolton et al., 2018). For example, designers, engineers, and clients can collaborate on design decisions, evaluate trade-offs, and align their objectives.

Furthermore, DT platforms support remote collaboration, which has become increasingly important in the context of globalised design practices. The ability to access real-time data and simulations from anywhere enables more flexible and efficient workflows.

5.5 User-Centric and Adaptive Environments

A notable finding is the role of Digital Twins in enabling user-centric design. By analysing data on occupant behaviour and preferences,

DT systems allow designers to create spaces that adapt to user needs. For instance, lighting and temperature settings can be customised based on individual preferences, enhancing comfort and satisfaction.

This adaptive capability aligns with the broader trend toward smart and responsive environments. By continuously learning from user interactions, DT systems can optimise performance and improve user experience over time (Fuller et al., 2020).

From a sustainability perspective, user-centric design contributes to more efficient resource use. For example, energy consumption can be reduced by tailoring system operation to actual occupancy patterns, rather than relying on fixed schedules.

5.6 Barriers to Implementation

Despite the numerous benefits, the analysis identifies several barriers to the adoption of Digital Twin technology in interior design.

Technical Complexity: The integration of DT systems requires advanced technical expertise, including knowledge of data analytics, IoT, and simulation tools. Many design professionals lack these skills, creating a barrier to adoption (Pärn et al., 2017).

High Implementation Costs: The cost of implementing DT systems, including hardware, software, and training, can be prohibitive, particularly for small design firms. This limits the accessibility of the technology and slows its adoption.

Data Interoperability Issues: The lack of standardised data formats and protocols

presents challenges for integrating DT systems with existing tools and platforms. This can result in data silos and reduced efficiency.

Organisational Resistance: Resistance to change is a common challenge in technology adoption. Design professionals may be reluctant to adopt DT systems due to perceived risks, lack of familiarity, or concerns about increased workload (Rogers, 2003).

Ethical and Privacy Concerns: The use of IoT sensors and data collection raises concerns about privacy and data security. Ensuring ethical use of data is critical for building trust and promoting adoption.

6. Discussion

The findings of this study highlight the transformative potential of Digital Twin technology in sustainable interior design, while also revealing significant challenges that must be addressed. This section interprets the findings in relation to the theoretical framework and broader literature, providing a deeper understanding of the implications for practice and research.

6.1 Digital Twin as a Socio-Technical Innovation

From a socio-technical perspective, Digital Twin technology represents more than a technical tool; it is a catalyst for organisational and cultural change. The integration of DT systems requires a reconfiguration of workflows, roles, and relationships within design practice (Trist, 1981).

The findings demonstrate that while DTs enhance design capabilities, their effectiveness depends on the ability of professionals to interpret and utilise the data. This underscores the importance of aligning technological innovation with human capabilities. Training and education are therefore critical components of successful DT integration.

Moreover, the collaborative nature of DT platforms reflects the interconnectedness of socio-technical systems. By facilitating communication and coordination among stakeholders, DTs contribute to more integrated and holistic design processes.

6.2 Adoption Dynamics and Diffusion of Innovation

The barriers identified in the findings can be understood through the lens of Diffusion of Innovation Theory (Rogers, 2003). For example, the perceived complexity of DT systems reduces their adoption, while the lack of observable benefits in early stages may discourage potential users.

To accelerate adoption, it is important to enhance the perceived relative advantage of DT technology by demonstrating its benefits through case studies and pilot projects. Increasing trialability and observability can also reduce uncertainty and build confidence among design professionals.

Additionally, the role of early adopters and opinion leaders is critical in influencing the adoption process. Design firms that successfully implement DT systems can serve as models for others, promoting wider diffusion.

6.3 Implications for Sustainable Design Practices

The integration of Digital Twin technology has significant implications for sustainable interior design. By enabling real-time monitoring, predictive analysis, and lifecycle assessment, DTs support more informed and effective sustainability strategies.

The findings suggest that DTs can help bridge the gap between design intent and operational performance, a common challenge in sustainable design. By providing continuous feedback, DT systems ensure that sustainability goals are maintained throughout the lifecycle of a space.

Furthermore, the emphasis on user-centric design aligns with the social dimension of sustainability, which focuses on human well-being and quality of life. By creating adaptive and responsive environments, DTs contribute to more sustainable and livable spaces.

6.4 Challenges and Strategies for Implementation

Addressing the challenges identified in the findings requires a multi-faceted approach:

- **Capacity Building:** Training programs and educational initiatives can equip design professionals with the necessary skills.
- **Cost Reduction:** Advances in technology and economies of scale may reduce costs over time.
- **Standardisation:** Developing common data standards can improve interoperability.

- **Policy Support:** Government incentives and regulations can promote adoption.

These strategies align with Sustainability Transition Theory, which emphasises the need for systemic change involving multiple actors and levels (Geels, 2002).

6.5 Contribution to Knowledge

This study contributes to the literature by providing a qualitative analysis of Digital Twin integration in interior design, a relatively underexplored area. By combining theoretical perspectives and empirical insights, the study offers a comprehensive understanding of the opportunities and challenges associated with DT technology.

7. Conclusion

This study has explored the integration of Digital Twin (DT) technology within sustainable interior design practices through a qualitative analysis of secondary data. The findings demonstrate that Digital Twin systems hold significant potential to transform interior design by enabling data-driven, adaptive, and sustainability-oriented decision-making processes. By facilitating real-time monitoring, predictive simulation, and lifecycle assessment, DT technologies provide designers with powerful tools to enhance environmental performance and occupant well-being.

One of the key contributions of this study is the identification of how Digital Twin technology supports a shift from traditional, static design approaches toward dynamic and responsive design environments. The ability

to simulate multiple design scenarios, monitor real-time performance, and continuously optimise systems allows designers to align design outcomes more closely with sustainability goals. This is particularly in interior spaces, where decisions related to materials, lighting, and environmental systems have long-term implications for energy consumption and user comfort.

The study also highlights the importance of understanding Digital Twin integration as a socio-technical process. Successful adoption depends not only on technological capabilities but also on the readiness of design professionals, organisational structures, and industry practices. The application of socio-technical systems theory and diffusion of innovation theory provides valuable insights into the factors influencing adoption, including perceived benefits, complexity, and compatibility with existing workflows.

Despite its potential, the widespread implementation of Digital Twin technology faces several challenges. High costs, lack of technical expertise, data interoperability issues, and resistance to change remain significant barriers. Addressing these challenges requires coordinated efforts across multiple levels, including education and training, development of standardised frameworks, and supportive policy interventions.

In conclusion, Digital Twin technology represents a promising pathway toward more sustainable and intelligent interior design practices. By bridging the gap between design intent and operational performance,

DT systems can contribute to more efficient, resilient, and human-centred built environments. Future research should focus on empirical studies involving design professionals, as well as the development of practical frameworks to support DT implementation in real-world design contexts.

References

- Bolton, A., Butler, L., Dabson, I., Enzer, M., Evans, M., Fenemore, T., & Webster, M. (2018). *The Gemini Principles*. Centre for Digital Built Britain.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five approaches* (4th ed.). Sage Publications.
- Fuller, A., Fan, Z., Day, C., & Barlow, C. (2020). Digital Twin: Enabling technologies, challenges and open research. *IEEE Access*, 8, 108952–108971. <https://doi.org/10.1109/ACCESS.2020.2998358>
- Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes. *Research Policy*, 31(8–9), 1257–1274. [https://doi.org/10.1016/S0048-7333\(02\)00062-8](https://doi.org/10.1016/S0048-7333(02)00062-8)
- Kang, M., & Guerin, D. A. (2009). The characteristics of interior designers who practice sustainable design. *Environment and Behaviour*, 41(2), 170–184. <https://doi.org/10.1177/0013916508315125>
- Lu, Q., Xie, X., Heaton, J., Parlikad, A. K., & Schooling, J. (2020). From BIM towards Digital Twin: Strategy and future development for smart asset management. *Automation in Construction*, 120, 103–117. <https://doi.org/10.1016/j.autcon.2020.103-117>
- Mannan, K.A., & Farhana, K.M. (2026). *The Principles of Qur'anic Research Methodology: Deriving the Process of Knowledge from Revelation*. KMF Publishers. Open Access (CC BY 4.0). DOI: <https://doi.org/10.64907/xkmf.book.pqrm.26.02.12>
- Pärn, E. A., Edwards, D. J., & Sing, M. C. (2017). The building information modelling trajectory in facilities management. *Automation in Construction*, 75, 45–55. <https://doi.org/10.1016/j.autcon.2016.12.003>
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.
- Trist, E. (1981). The evolution of socio-technical systems. *Occasional Paper*, 2, 1–67.