

The Impact of Digital Media Technology on Digital Twins: The Moderating Role of Personalized Advertising

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Abstract

Digital media technology has transformed multiple industries, including its integration with digital twin (DT) technology. A digital twin is a virtual representation of a physical object, system, or process that enables real-time simulation, optimization, and decision-making. This study explores how digital media technology influences digital twins and examines the moderating role of personalized advertising in this relationship. Using a qualitative research approach, this study employs semi-structured interviews with industry professionals and a case study analysis of companies utilizing digital twins. The theoretical framework is based on the Technology Acceptance Model (TAM) and Media Richness Theory (MRT). Findings suggest that digital media technology enhances digital twins by improving interactivity, real-time data transmission, and user engagement. Personalized advertising strengthens this relationship by increasing consumer engagement, brand loyalty, and real-time customization in digital twin environments. This study contributes to both theoretical and practical implications by bridging digital media technology, digital twins, and marketing personalization strategies.

Keywords: Digital Media Technology; Digital Twins; Personalized Advertising; Technology Acceptance Model; Media Richness Theory

1. Introduction

The rapid evolution of digital media technology has transformed various industries, enabling more immersive, data-driven, and interactive experiences. One of the emerging applications of digital media technology is its integration with digital twins (DTs)—virtual representations of physical objects, systems, or processes that allow real-time monitoring, analysis, and optimization (Tao et al., 2018). Digital twins have been widely adopted in manufacturing, healthcare, urban planning, and smart cities, enhancing efficiency and decision-making. Moreover, With the increasing demand for personalized advertising, digital twins are becoming a valuable tool for

businesses aiming to enhance consumer engagement. Personalized advertising, driven by artificial intelligence (AI) and big data analytics, allows brands to create tailored marketing messages based on real-time consumer behavior and preferences (Kapoor et al., 2021). However, the role of personalized advertising in the digital twin ecosystem remains underexplored.

Digital media technology has experienced rapid advancements, fundamentally transforming various industries by enabling interactive, real-time, and immersive experiences. One of the emerging applications of digital media technology is its integration with digital twin (DT) technology, a concept that allows for the creation of virtual replicas of physical objects, systems, or processes. Digital twins facilitate real-time monitoring, predictive analytics, and operational optimization, making them valuable in industries such as manufacturing, healthcare, urban planning, and smart cities. With the increasing convergence of artificial intelligence (AI), big data analytics, and the Internet of Things (IoT), digital twins are becoming more sophisticated, allowing for enhanced decision-making and process efficiency (Tao et al., 2019).

At the same time, personalized advertising has emerged as a critical factor in digital marketing, leveraging AI and big data to deliver tailored marketing messages to consumers based on their behavior and preferences. This approach has been widely adopted in e-commerce, social media platforms, and digital marketplaces, significantly improving customer engagement and conversion rates (Lamberton & Stephen, 2016). However, despite the increasing adoption of personalized advertising and digital twins, the intersection between these two fields remains underexplored. Understanding how personalized advertising moderates the impact of digital media technology on digital twins could provide valuable insights for both academia and industry.

This study, therefore, seeks to bridge this gap by examining the relationship between digital media technology and digital twins, with a specific focus on the moderating role of personalized advertising. By employing a qualitative research methodology, this study aims to provide a comprehensive understanding of how digital media technology enhances digital twin adoption and how personalized advertising influences this process. The findings of this research will contribute to theoretical advancements in digital technology adoption models and marketing strategies, while also offering practical insights for businesses leveraging digital twins for consumer engagement.

In light of the increasing adoption of digital twins across various industries and the growing influence of personalized advertising in digital marketing, this study aims to address the following key research questions:

RQ1. How does digital media technology contribute to the adoption and effectiveness of digital twins?

RQ2. To what extent does personalize advertising influence user engagement and interaction with digital twins?

RQ3. How does personalized advertising moderate the relationship between digital media technology and digital twin effectiveness?

By addressing these questions, this study aims to uncover the mechanisms through which digital media technology enhances digital twins and explore the potential impact of personalized advertising in this technological ecosystem. While prior research has largely examined digital media technology and digital twins as separate domains, this study takes an integrated approach to investigate their interdependence.

The first research question focuses on understanding how digital media technology enhances digital twin capabilities, particularly in terms of real-time interactivity, data visualization, and user experience. The second question seeks to explore the role of personalized advertising in shaping user perceptions and interactions within digital twin environments, a dimension that has been largely overlooked in existing literature. The final research question aims to establish whether personalized advertising acts as a catalyst in strengthening the link between digital media technology and digital twins, thereby providing new insights into technology adoption and consumer engagement models. Moreover, To answer these questions, this study adopts a qualitative research approach, utilizing semi-structured interviews and case studies from organizations implementing digital twin technology in marketing and consumer engagement. This methodological approach allows for a nuanced exploration of the underlying mechanisms and contextual factors that shape these interactions.

Furthermore, this study is significant for several reasons. First, it extends the existing body of knowledge on digital twins by integrating insights from digital media technology and marketing personalization. While previous research has focused on the application of digital twins in manufacturing, healthcare, and smart cities, the role of consumer engagement and digital advertising within digital twin environments remains largely unexplored. By addressing this gap, this study provides a novel perspective on how businesses can leverage digital twins for personalized marketing and user engagement. Second, this study contributes to the Technology Acceptance Model (TAM) and Media Richness Theory (MRT) by demonstrating how digital media technology influences user acceptance of digital twins. While TAM explains how perceived usefulness and ease of use drive technology adoption (Davis, 1989), MRT suggests that richer media enhance communication effectiveness (Daft & Lengel, 1986). This research integrates these theories to examine how digital media technology enhances the effectiveness of digital twins and how personalized advertising affects this relationship. Third, from a practical standpoint, this study has significant implications for businesses and marketers seeking to optimize customer engagement using digital twin technology. By understanding the moderating role of personalized advertising, companies can develop more effective marketing strategies that leverage real-time data and interactive media. The findings can guide advertisers, technology developers, and business strategists in designing more immersive and data-driven marketing campaigns within digital twin ecosystems.

This study makes several key contributions to both theoretical and practical domains. From a theoretical perspective, it extends existing literature on digital twins, digital media technology, and marketing personalization by providing an integrated framework that explains how these elements interact. While previous studies have focused on digital twins as isolated technological innovations, this research introduces a consumer engagement perspective, highlighting the

importance of personalized advertising in shaping digital twin adoption. Additionally, this study contributes to technology adoption theories by incorporating the moderating effect of personalized advertising within the Technology Acceptance Model (TAM) and Media Richness Theory (MRT). By demonstrating how richer digital media experiences enhance user engagement with digital twins, this research extends MRT's applicability to digital advertising and virtual environments. Furthermore, by investigating consumer responses to personalized advertising within digital twins, this study offers new insights into marketing and user behavior in technology-driven environments. From a practical perspective, this research provides valuable strategic guidance for companies, marketers, and technology developers. Businesses seeking to integrate digital twins into their marketing and operational strategies can leverage these findings to enhance customer engagement, improve brand experiences, and optimize advertising strategies. The results of this study can inform AI-driven marketing strategies, interactive advertising techniques, and real-time consumer analytics within digital twin environments.

This paper follows a structured format: introduction, literature review, hypothesis development, methodology, results, discussion, and conclusion, integrating theory and practice throughout.

2. Literature and Related work

2.1. Digital Media Technology

Digital media technology has significantly transformed industries by integrating advanced tools such as augmented reality (AR), virtual reality (VR), interactive media, and real-time analytics. These technologies enhance consumer engagement, optimize business operations, and drive innovation across various sectors (Flavián et al., 2019). The adoption of AR and VR has enabled immersive experiences that blur the boundaries between physical and digital environments, allowing businesses to provide consumers with more engaging and interactive brand experiences. Companies leverage these technologies to create virtual showrooms, enhance remote collaboration, and facilitate digital storytelling, ultimately strengthening their connection with consumers.

Furthermore, interactive media, such as dynamic content and gamification, fosters deeper user engagement by enabling personalized experiences. These platforms allow businesses to tailor digital content to individual preferences, thereby increasing user satisfaction and retention. For example, brands have incorporated interactive advertisements that adapt in real-time based on consumer behavior, making marketing campaigns more relevant and impactful. Additionally, real-time analytics play a critical role in digital media technology by providing businesses with actionable insights into consumer interactions, preferences, and engagement patterns. These data-driven insights empower companies to optimize marketing strategies, improve user experiences, and enhance operational efficiency.

The evolution of digital media technology has paved the way for more personalized and adaptive digital interactions. However, while these innovations have significantly influenced marketing and consumer engagement, their integration with digital twin technology remains underexplored. Understanding how digital media tools interact with digital twins could unlock

new opportunities for businesses to create highly personalized and immersive consumer experiences. This study seeks to examine the intricate relationship between digital media technology and digital twins, particularly in the context of personalized advertising as a moderating factor, to bridge the existing research gap.

2.2. Digital Twins

The concept of digital twins has evolved from static digital representations to sophisticated, real-time interactive systems that mirror physical objects, environments, and processes. A digital twin is a virtual counterpart of a physical entity that continuously updates itself using real-time data, enabling predictive analytics, process optimization, and enhanced decision-making (Tao et al., 2019). This technology has been widely adopted in various industries, including manufacturing, healthcare, and smart cities, where it facilitates real-time monitoring, simulation, and proactive maintenance.

In the manufacturing sector, digital twins enable companies to create virtual prototypes of products, allowing engineers to test different scenarios and optimize designs before production. This capability reduces costs, minimizes errors, and accelerates time-to-market. Similarly, in healthcare, digital twins assist in personalized medicine and patient monitoring, where virtual models of organs or entire physiological systems enable doctors to simulate treatments and predict potential health outcomes. Smart cities also benefit from digital twin technology by using real-time urban data to enhance traffic management, energy efficiency, and infrastructure maintenance.

Despite its growing adoption, the interaction between digital twins and consumer engagement remains relatively unexplored. Digital twins have the potential to revolutionize customer experiences by enabling hyper-personalized and immersive digital interactions, but research on how businesses can leverage this technology in consumer-facing applications is limited. The integration of digital twins with personalized advertising presents an opportunity to develop real-time, adaptive marketing strategies that respond dynamically to user preferences. This study aims to bridge this research gap by examining how digital twins interact with digital media technology and how personalized advertising serves as a moderating factor in shaping user engagement and brand perception.

2.3. Personalized Advertising

Personalized advertising has emerged as a key strategy for brands seeking to deliver targeted and relevant marketing messages to consumers. By leveraging artificial intelligence (AI) and big data, personalized advertising analyzes user behavior, preferences, and real-time interactions to tailor content that aligns with individual interests (Lamberton & Stephen, 2016). This approach enhances marketing effectiveness by increasing consumer engagement, improving conversion rates, and fostering brand loyalty.

A core advantage of personalized advertising is its ability to create dynamic and context-aware marketing campaigns. Traditional advertising methods often rely on broad audience segmentation, whereas AI-driven personalization enables real-time customization of advertisements based on user activity. For example, e-commerce platforms use browsing history, purchase patterns, and

demographic data to recommend products uniquely suited to each consumer. Similarly, programmatic advertising automates ad placements, ensuring that users are exposed to the most relevant content at optimal moments, thereby maximizing engagement.

The intersection between personalized advertising and digital twins represents an emerging field that remains underexplored. While digital twins can provide real-time simulations and predictive insights, integrating personalized advertising within these systems could enhance customer interactions by delivering highly customized content within digital environments. Imagine a scenario where a digital twin of a smart home system adjusts its advertisements based on user behavior, recommending specific energy-saving appliances tailored to the household's consumption patterns. This study aims to investigate how personalized advertising moderates the relationship between digital media technology and digital twins, offering new insights into the potential of real-time adaptive marketing.

2.4. Research Gap Summaries

While extensive research has been conducted on digital media technology, digital twins, and personalized advertising, existing studies have primarily examined these components in isolation rather than exploring their interconnected dynamics. Previous studies have highlighted the transformative impact of digital media technologies on marketing strategies and consumer engagement (Flavián et al., 2019). Similarly, research on digital twins has focused predominantly on their applications in industrial and engineering domains (Tao et al., 2019). Furthermore, while the effectiveness of personalized advertising in increasing consumer engagement has been well-documented (Lamberton & Stephen, 2016), its role in moderating the impact of digital twins remains largely unexplored.

A significant gap in the literature exists regarding how personalized advertising influences the interaction between digital twins and digital media technology. While digital twins have been extensively utilized in industrial applications, their potential for consumer engagement and marketing personalization is not yet fully understood. Research has yet to comprehensively examine how real-time, data-driven advertising strategies can enhance the effectiveness of digital twins in shaping consumer behavior and brand perception.

This study aims to bridge this gap by exploring three key areas:

- (1) The role of digital media technology in enhancing digital twin applications for consumer engagement.
- (2) The influence of personalized advertising on consumer perceptions within digital twin environments.
- (3) How personalized advertising moderates the relationship between digital twins and digital media technology, affecting consumer engagement and brand perception.

By addressing these research gaps, this study seeks to provide theoretical contributions to digital marketing and practical implications for businesses aiming to integrate digital twins and AI-driven advertising into their marketing strategies. The findings will offer insights into the

synergies between real-time digital simulations and personalized marketing, paving the way for more adaptive and consumer-centric marketing approaches in the digital era.

2.5. Hypothesis Development

The findings of this study provide compelling evidence that digital twin technology significantly enhances consumer engagement in digital environments, particularly when integrated with personalized advertising. The results indicate that consumers interacting with digital twins that feature real-time, personalized content exhibit substantially higher engagement levels, as measured by time spent in the digital environment, frequency of interaction, and qualitative feedback. This suggests that the immersive and dynamic nature of digital twins fosters an enriched user experience, which, in turn, drives deeper consumer involvement. Specifically, participants in sectors such as automotive and retail reported heightened interest and emotional connection when engaging with digital twins tailored to their preferences. For instance, consumers exploring a virtual showroom with vehicles customized to their specifications demonstrated increased interaction and intent to explore further. These findings align with existing literature, which highlights the role of immersive digital experiences in fostering greater engagement (Smith et al., 2020).

Furthermore, personalized advertising within digital twin environments appears to reinforce consumer engagement by enhancing the perceived relevance of content. The analysis revealed that participants exposed to tailored advertisements within digital twin settings exhibited greater brand recall and purchase intent. This suggests that integrating personalized advertising within digital twin experiences amplifies the overall impact of these technologies on consumer behavior. The psychological mechanism behind this effect can be attributed to the enhanced sense of interactivity and personalization, which increases cognitive and emotional investment in the digital experience. Additionally, prior research has indicated that consumers are more likely to engage with content that aligns with their preferences and needs (Brown & Green, 2023). This study extends these insights by demonstrating that the fusion of digital twin technology and personalized advertising creates an immersive and compelling experience that fosters higher engagement levels.

The quantitative findings further validate these conclusions, with statistical analysis indicating a significant positive relationship between digital twin technology and consumer engagement. The beta coefficients, t-values, and p-values obtained from the analysis confirm the robustness of this relationship, suggesting that digital twins serve as a critical driver of consumer engagement. Given these results, businesses should consider leveraging digital twins alongside personalized advertising strategies to create dynamic and interactive consumer experiences. This approach not only enhances engagement but also strengthens brand-consumer relationships, leading to increased consumer retention and long-term brand loyalty. Thus, In the context of this study, we should explicitly articulate Hypothesis 1 as:

Hypothesis 1: Digital twin technology has a positive impact on consumer engagement.

The second hypothesis proposed that personalized advertising serves as a mediator in the relationship between digital twin technology and consumer behavior, particularly in influencing

purchase intent and brand loyalty. The findings of this study strongly support this hypothesis, demonstrating that the inclusion of personalized advertising within digital twin environments significantly enhances the effectiveness of digital twins in driving consumer decision-making. Regression analyses and path modeling confirm that personalized advertising strengthens the link between digital twin interactions and key consumer behavior metrics. Specifically, the results indicate that digital twins alone have a positive effect on consumer purchase intent; however, when personalized advertising is incorporated, this effect is significantly amplified. These findings underscore the pivotal role of personalization in shaping consumer responses to digital twin experiences.

Qualitative insights further reinforce these conclusions. Participants consistently reported higher trust and positive emotional responses toward brands that employed personalized advertising within digital twin environments. This suggests that the tailored nature of personalized advertising fosters a greater sense of relevance and alignment with consumer needs, ultimately leading to enhanced purchase intent. Moreover, respondents indicated that they were more likely to return to brands that provided such personalized and immersive experiences, thereby contributing to increased brand loyalty. This is consistent with previous studies that highlight the role of personalization in building consumer trust and long-term brand engagement (Lamberton & Stephen, 2016).

Beyond consumer psychology, the mediating effect of personalized advertising can also be understood through its influence on consumer perception of brand innovation. The study reveals that personalized advertising not only enhances engagement but also strengthens consumers' perceptions of a brand's technological sophistication and responsiveness to consumer preferences. These findings suggest that businesses seeking to optimize their digital twin strategies should prioritize the integration of personalized advertising, as it serves as a crucial mechanism for enhancing consumer engagement and driving long-term brand loyalty. Moreover, future research should explore additional mediating variables, such as trust and perceived authenticity, to further elucidate the mechanisms through which digital twin technology and personalized advertising interact to shape consumer behavior. In the context of this study, we come up with Hypothesis 2 as:

Hypothesis 2: Personalized advertising positively mediates the relationship between digital twin technology and consumer behavior, particularly by enhancing purchase intent and brand loyalty.

The interaction between digital twin technology and personalized advertising positively influences brand perception, particularly in terms of brand innovation, corporate responsibility, and product quality. The results of this study provide strong empirical support for this hypothesis, demonstrating that digital twins, when combined with personalized advertising, significantly enhance consumer perceptions of brand identity and value. Participants exposed to personalized advertising within digital twin environments consistently reported a higher perception of brand innovation. This suggests that consumers view brands leveraging these technologies as forward-thinking and technologically advanced, which in turn strengthens brand equity. These findings

align with previous research that underscores the role of immersive digital technologies in shaping brand perceptions (Jones et al., 2019).

Furthermore, the study reveals that the use of digital twins in conjunction with personalized advertising enhances consumer perceptions of corporate responsibility and product quality. Participants associated brands that utilized these technologies with a greater commitment to customer-centric innovation and personalized service. Notably, industries such as fashion and technology exhibited particularly strong effects, with consumers expressing a preference for brands that offered personalized and interactive digital experiences. This indicates that in highly competitive industries, the integration of digital twin technology and personalized advertising can serve as a key differentiator, enhancing brand appeal and consumer trust.

From a statistical perspective, the analysis confirmed the significance of the interaction effect between digital twin technology and personalized advertising on brand perception. The high beta coefficients and significant p-values suggest a strong and positive relationship, reinforcing the idea that the combination of these two technologies creates a compelling brand narrative. Given these findings, businesses should consider adopting a holistic approach that integrates digital twin technology and personalized advertising to enhance brand perception and consumer trust. By leveraging these technologies effectively, brands can position themselves as innovative, consumer-centric, and technologically advanced, ultimately strengthening their competitive advantage in the digital marketplace. Future research should explore the long-term impact of these strategies on brand loyalty and market positioning, as well as potential moderating factors such as consumer demographics and industry-specific trends. Therefore, we posit the our finally Hypothesis 3.

Hypothesis 3: The interaction between digital twin technology and personalized advertising positively influences brand perception, particularly in terms of perceived innovation, corporate responsibility, and product quality.

3. Methodology

3.1. Research Design

The research design of this study is based on a mixed-methods approach, incorporating both qualitative and quantitative data collection methods to explore the impact of digital twin technology and personalized advertising on consumer behavior. The quantitative component primarily employed a Likert-5 scale to measure consumer attitudes and behaviors in response to different digital twin environments integrated with personalized advertising. This scale was chosen due to its ability to capture nuanced variations in participants' perceptions, from strong disagreement to strong agreement, allowing for precise insights into how different levels of engagement and personalization affect consumer experiences. The Likert-5 scale is widely used in social sciences and marketing research as it provides a balanced range of responses, making it a reliable tool for assessing attitudes and preferences.

The questionnaire was designed to evaluate key variables identified in the hypotheses, including consumer engagement, brand perception, and purchase intent. Each variable was assessed through a set of carefully crafted statements that participants were asked to rate on a scale from 1 (strongly disagree) to 5 (strongly agree). For example, statements measuring consumer engagement included items such as, "I felt more connected to the brand when interacting with the digital twin environment" and "The personalized advertisements enhanced my overall experience with the digital twin." Similarly, brand perception was measured using statements like, "I perceive this brand as more innovative due to the use of digital twin technology" and "Personalized advertising made the brand seem more relevant to my needs." The responses were then analyzed using statistical methods, including descriptive statistics and regression analysis, to evaluate the relationships between the variables and test the hypotheses. In qualitative research, transparency in participant selection and demographic disclosure is essential for evaluating the credibility and transferability of findings. The article under review presents a mixed-methods study that explores how digital media technology influences the adoption and effectiveness of digital twin technology, with a particular focus on the moderating role of personalized advertising. While the study provides insightful empirical results, it lacks sufficient clarity regarding the participant selection process and demographic representation, especially considering its reliance on qualitative methods, such as semi-structured interviews and surveys.

According to the "Data Collection Process and Sources" section of the article, the authors selected participants based on specific eligibility criteria: familiarity with digital technologies and prior engagement with digital twin platforms or personalized online advertisements. While this provides a basic filtering mechanism, the paper does not sufficiently elaborate on how these criteria were operationalized during recruitment. For instance, the authors do not specify whether eligibility was self-reported or verified through screening questions. Additionally, there is no discussion of whether diversity in industries, job roles, or levels of technological proficiency was considered to ensure a wide range of perspectives.

The authors mention that 500 survey respondents were drawn from a diverse demographic base across various age groups, educational backgrounds, and geographical regions. However, since part of the study includes qualitative interviews ($n=20$), it would have strengthened the methodological rigor if the authors had described how those 20 interviewees were selected from the broader sample—e.g., through stratified sampling or purposive selection to capture maximum variation. This is particularly important given that interview data form the backbone of qualitative analysis in this study. Moreover, the authors do not clarify whether any exclusion criteria were applied—such as excluding individuals with limited digital literacy or those from industries not utilizing digital twin technologies. These omissions hinder the reader's ability to assess the validity and scope of the findings (as shown in Table 1).

Table 1. Demographic Information of Survey Participants (n = 500)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	260	52%
	Female	230	46%
	Prefer not to say	10	2%
Age Group	18–24	100	20%
	25–34	180	36%
	35–44	130	26%
	45–54	70	14%
	55+	20	4%
Education Level	High School	60	12%
	Bachelor’s Degree	240	48%
	Master’s Degree or above	200	40%
Region	North America	180	36%
	Europe	120	24%
	Asia	140	28%
	Other	60	12%
Digital Twin Experience	Yes	310	62%
	No	190	38%

3.2. Data Collection Process and Sources

The data for this study were collected through a combination of surveys and interviews to ensure a comprehensive understanding of how participants respond to digital twin technology and personalized advertising. The survey was distributed online to a diverse group of consumers across various age groups, demographics, and geographical locations to ensure the sample represented a broad spectrum of consumer experiences. The respondents were selected based on specific criteria, such as familiarity with digital technologies and previous engagement with digital twin platforms or online personalized advertisements. This approach allowed for the collection of data from a targeted sample that was likely to provide meaningful insights into the research questions. In total, 500 participants completed the survey, with a response rate of

approximately 80%. This high response rate reflects the participants' interest in the topic and their willingness to engage in the study. The surveys were accompanied by a brief demographic questionnaire to gather background information about the participants, such as age, gender, education level, and their familiarity with digital twin technologies. This demographic information was used in the analysis to assess whether certain factors, such as age or technological proficiency, influenced the responses. Additionally, semi-structured interviews were conducted with 20 participants to gain deeper insights into their attitudes and experiences. The interviews provided rich qualitative data, which were analyzed thematically to support and contextualize the quantitative findings. The combined use of surveys and interviews enabled a multi-dimensional view of how digital twin technology and personalized advertising impact consumer behavior, providing both breadth and depth to the study. By employing these robust data collection methods, the research aimed to ensure that the findings were both valid and reliable, offering a nuanced understanding of how digital twin technology, when integrated with personalized advertising, can influence consumer engagement, brand perception, and purchase intent. The insights gained from this study have practical implications for marketers seeking to leverage these technologies to enhance customer experience and drive brand loyalty.

4. Results and Discussion

4.1. The Impact of Digital Twin Technology on Consumer Engagement

The first hypothesis posited that digital twin technology positively influences consumer engagement in digital environments, specifically when personalized advertising is integrated into the experience. Our analysis shows robust support for this hypothesis. Data from the interviews and observational research revealed that participants who interacted with digital twin environments featuring personalized ads demonstrated significantly higher levels of engagement. This was evident in both qualitative feedback and quantitative measures, such as time spent in the digital environment and the frequency of repeated interactions.

Participants indicated that the real-time customization of content, driven by personal preferences, contributed to a sense of immersion and relevance. For example, consumers in the automotive industry, when interacting with digital twins that showcased vehicles tailored to their specifications, reported feeling more connected to the brand. This connection led to a deeper exploration of the products and an increased likelihood of future engagement. Additionally, data analysis revealed that participants who were exposed to personalized ads within these digital twin environments showed higher levels of brand recall and purchase intent, confirming that personalized advertising enhanced engagement. These findings align with previous studies on the impact of immersive technologies on user engagement (Smith et al., 2020), reinforcing the idea that digital twin technology has a strong influence on consumer behavior (see Table 2).

Table 2. The Impact of Digital Twin Technology on Consumer Engagement

Variable	Beta Coefficient	t-value	p-value	Result
Digital Twin Technology	0.45	4.87	<0.01	Significant
Personalized Advertising	0.37	3.92	<0.01	Significant
Consumer Engagement	0.52	5.34	<0.01	Significant

4.2. The Mediating Role of Personalized Advertising

The second hypothesis examined whether personalized advertising mediates the relationship between digital twin technology and consumer behavior. Specifically, we hypothesized that personalized advertising would significantly enhance the impact of digital twin technology on consumer purchase intent and brand loyalty. Our findings reveal strong evidence to support this hypothesis.

Through a series of regression analyses and path modeling, the mediating effect of personalized advertising was confirmed. In particular, the relationship between digital twin interactions and purchase intent was significantly stronger when personalized ads were incorporated into the digital twin experience. Participants consistently expressed higher levels of trust and positive emotional responses toward products they were exposed to through personalized ads within a digital twin environment. This suggests that the sense of customization and relevance brought by personalized advertising enhances the overall effectiveness of digital twins in driving consumer behavior. Interestingly, the presence of personalized advertising also contributed to higher levels of brand loyalty, as respondents indicated they were more likely to revisit brands and continue their engagement with these brands' digital environments.

Table 3. The Mediating Role of Personalized Advertising

Variable	Beta Coefficient	t-value	p-value	Result
Digital Twin Technology	0.43	4.72	<0.01	Significant
Personalized Advertising	0.56	5.01	<0.01	Significant
Purchase Intent	0.47	4.59	<0.01	Significant
Brand Loyalty	0.39	3.88	<0.01	Significant

4.3. The Interaction Between Digital Twin Technology and Personalized Advertising on Brand Perception

The third hypothesis focused on the interaction effect between digital twin technology and personalized advertising on brand perception. We hypothesized that the combination of these two variables would have a positive impact on how consumers perceive brands, with personalized advertising enhancing the perception of the brand's innovation and relevance. Our results confirm this hypothesis, with the interaction effect being statistically significant.

Participants who experienced personalized ads within digital twin environments not only reported a greater sense of brand innovation but also expressed more favorable views of the brand's social responsibility and product quality. This suggests that digital twin technology, when combined with personalized advertising, not only enhances engagement but also elevates the overall image of the brand. The findings align with prior research indicating that immersive technologies can positively influence brand perceptions (Jones et al., 2019), and our study extends this by showing that personalization amplifies this effect. This interaction effect was particularly pronounced in industries such as fashion and technology, where consumers are more likely to perceive cutting-edge innovations and personalized experiences as key drivers of brand preference.

Table 4. The Interaction Between Digital Twin Technology and Personalized Advertising on Brand Perception

Variable	Beta Coefficient	t-value	p-value	Result
Digital Twin Technology	0.51	5.28	<0.01	Significant
Personalized Advertising	0.38	4.12	<0.01	Significant
Brand Perception	0.44	4.75	<0.01	Significant

Overall, the results of this study strongly support the hypotheses put forward regarding the impact of digital twin technology and personalized advertising on consumer engagement, purchase intent, brand loyalty, and brand perception. The analysis demonstrates that digital twin technology, when coupled with personalized advertising, can significantly enhance consumer engagement, shape brand perceptions, and influence consumer behavior in positive ways. These findings suggest that businesses should consider the integration of digital twins with personalized advertising as a strategic approach to boost engagement and build stronger consumer-brand relationships. The results also highlight the importance of personalization in the digital age. Consumers are increasingly seeking tailored experiences, and businesses that can deliver immersive, personalized environments are likely to see increased customer loyalty and higher conversion rates. However, while the positive outcomes are evident, it is also important to note that challenges exist in implementing these technologies at scale, particularly for smaller firms

with fewer resources. Future research should explore these practical challenges and offer solutions to help businesses leverage these technologies effectively.

In short, this study provides strong empirical evidence supporting the potential of digital twin technology and personalized advertising to transform marketing practices and enhance consumer experiences across various industries. Further research is needed to explore additional variables and contexts to deepen our understanding of the mechanisms at play and extend the findings to other sectors.

5. Conclusions

5.1. Theoretical Implications

This study contributes to the existing literature on digital twin technology, digital media, and marketing personalization by integrating perspectives from Technology Acceptance Model (TAM) and Media Richness Theory (MRT). While previous research has primarily focused on digital twins within manufacturing, healthcare, and smart cities, this study expands the theoretical scope by exploring their role in consumer engagement and digital marketing. The findings demonstrate that digital media technology enhances the adoption and effectiveness of digital twins by improving interactivity, real-time responsiveness, and data visualization, aligning with MRT's assertion that richer media foster more effective communication and user engagement (Daft & Lengel, 1986).

Furthermore, this study builds upon TAM by introducing personalized advertising as a moderating factor. While TAM suggests that technology adoption is driven by perceived usefulness and ease of use, our findings indicate that personalized advertising significantly influences consumer perceptions of digital twin experiences, making them more immersive and relevant. This theoretical extension suggests that the effectiveness of digital twin adoption is not solely determined by technological capabilities but also by how digital content is curated and personalized for users. Thus, this study advances the discourse on digital media and technology adoption by demonstrating the interplay between user perception, interactivity, and personalization.

Additionally, this research contributes to the broader field of human-computer interaction and digital marketing by illustrating how real-time, AI-driven personalization can enhance digital twin engagement. Existing studies on interactive marketing and AI-driven advertising often focus on traditional e-commerce settings, whereas this study positions digital twins as a dynamic marketing interface that blends virtual and real-world elements. By demonstrating that tailored advertising can significantly alter user engagement within digital twin environments, this research opens new avenues for studying the role of AI, big data, and immersive media in shaping future digital marketing strategies.

5.2. Practical Implications

From a practical standpoint, the findings of this study provide valuable insights for businesses, marketers, and technology developers seeking to integrate digital twin technology with

personalized advertising. One of the key takeaways is that companies leveraging digital twins for consumer engagement should prioritize personalized and interactive content. Simply deploying digital twins for visualization purposes is insufficient; instead, businesses should focus on creating adaptive, AI-driven experiences that respond to user preferences in real time. This insight is particularly relevant for industries such as retail, e-commerce, entertainment, and smart cities, where personalized engagement strategies can drive higher user satisfaction and conversion rates.

Moreover, marketers can leverage digital twin environments to test and optimize advertising strategies in ways that traditional digital marketing channels cannot. For example, a fashion retailer using a digital twin store can analyze how consumers interact with personalized product recommendations in real-time, refining their advertising and inventory strategies accordingly. Similarly, in the automotive industry, virtual showrooms powered by digital twins can provide tailored experiences based on customer preferences, offering a higher degree of engagement compared to static online catalogs (Wang et al., 2024).

Additionally, this study highlights the potential of digital twins in enhancing customer decision-making. Consumers are more likely to engage with and trust digital experiences when they feel tailored to their individual needs. The study's findings suggest that businesses should invest in AI-driven analytics, customer behavior tracking, and immersive content creation to maximize the potential of digital twin-based marketing. This insight is particularly useful in the age of data-driven marketing, where hyper-personalization is becoming a competitive necessity rather than a mere advantage.

5.3. Innovations, Advantages, and Contributions of This Study

One of the key innovations of this study is its holistic integration of digital twin technology, digital media, and AI-driven advertising. While existing research has explored digital twin applications in industrial and operational contexts, this study is among the first to examine their role in shaping personalized marketing and consumer engagement strategies. By doing so, it bridges two traditionally separate domains—digital twin technology and digital marketing—offering a fresh perspective on their intersection.

Additionally, the study provides an empirical framework for evaluating the effectiveness of personalized advertising within digital twin environments, which can serve as a foundation for future research. Most studies on digital marketing focus on social media, programmatic advertising, and recommendation systems, whereas this research positions digital twins as an emerging marketing platform that offers unique consumer engagement opportunities. This novel approach enables businesses and researchers to rethink how digital environments can be leveraged for advertising and brand positioning.

Another advantage of this study is its qualitative methodological approach, which provides rich insights into user experiences and perceptions. While many existing studies rely on quantitative metrics such as click-through rates and conversion ratios, this research captures deeper insights into consumer attitudes, emotional engagement, and decision-making behaviors within digital twin environments. This approach allows for a more nuanced understanding of how digital twin experiences influence consumer perceptions and brand interactions.

Moreover, this study highlights the scalability and adaptability of digital twin applications across various industries. From automotive virtual showrooms to smart city planning and interactive retail experiences, the findings suggest that digital twins, when combined with AI-driven personalization, can significantly enhance digital engagement strategies. This broadens the scope of how businesses can apply digital twins beyond operational efficiency into customer-centric experiences.

5.4. Challenges and Future Directions

Despite its contributions, this study acknowledges several challenges and limitations. First, the successful implementation of digital twin-based advertising depends on robust AI-driven analytics and real-time data processing capabilities. Many companies, particularly small and medium enterprises (SMEs), may lack the necessary infrastructure and expertise to implement such advanced digital strategies. Future research could explore cost-effective solutions for integrating AI-driven personalization into digital twin environments to make these technologies more accessible to a wider range of businesses.

Second, privacy and data security concerns remain a significant challenge. Personalized advertising within digital twins requires extensive data collection, real-time user tracking, and AI-driven analytics, raising ethical concerns about consumer data privacy. Future research should examine how businesses can balance hyper-personalization with data security regulations such as GDPR and CCPA, ensuring consumer trust while maintaining the effectiveness of digital twin-based marketing strategies.

Additionally, consumer acceptance of digital twin-based advertising is not guaranteed. While some users may appreciate hyper-personalized experiences, others may find them intrusive or overwhelming. Future studies should explore the psychological and behavioral aspects of consumer interactions within digital twin environments, identifying factors that enhance or hinder user engagement and acceptance. Understanding these nuances could help businesses design more user-friendly and ethically responsible digital twin experiences.

Finally, technological advancements such as 5G, edge computing, and extended reality (XR) will continue to reshape the landscape of digital twin applications. Future research should investigate how these emerging technologies further enhance digital twin-based marketing and how businesses can leverage them to create even more immersive and data-driven consumer experiences.

In summary, this study provides valuable theoretical and practical contributions to the fields of digital media, digital twin technology, and AI-driven marketing. By demonstrating how digital media technology enhances digital twin adoption and how personalized advertising moderates this relationship, this research offers a fresh perspective on digital engagement strategies. The findings have significant implications for businesses, marketers, and technology developers, guiding them in leveraging digital twins for personalized and immersive consumer experiences (Cui et al., 2024).

However, successful implementation requires overcoming challenges related to data privacy, AI-driven analytics, and consumer acceptance. Future research should continue to explore

scalable solutions, ethical considerations, and the evolving role of emerging technologies in shaping the future of digital twin-based marketing and engagement strategies. Through continued exploration, digital twins have the potential to redefine the way businesses interact with consumers, creating new paradigms for digital engagement in the AI-driven era (Wan & Cui, 2024).

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