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Mixed reality in U.S. retail: A review of immersive shopping experiences, customer engagement, and potential economic implications

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Abstract

This study aims to explore the transformative impact of Mixed Reality (MR) technologies in the U.S. retail sector. It focuses on analyzing how MR reshapes shopping experiences, enhances customer engagement, and influences the economic landscape of retail. The methodology encompasses a comprehensive literature review, utilizing academic journals, conference proceedings, and industry reports. The search strategy involved keyword searches and manual screening, with inclusion and exclusion criteria set to filter relevant literature. The selection criteria prioritized recent studies to capture the latest trends in MR technology. The key findings reveal that MR technologies have evolved significantly, offering immersive and interactive shopping experiences that revolutionize customer engagement and satisfaction. The economic implications of MR in retail are profound, indicating substantial market growth and financial opportunities for retailers. However, the adoption of MR also presents challenges, including the need for integration into existing retail models and the development of user-friendly interfaces. The study also highlights the importance of regulatory frameworks and standardization in the successful implementation of MR technologies in retail. In conclusion, MR technologies hold great potential for the retail sector, offering innovative ways to engage customers and enhance their shopping experiences. However, realizing these opportunities requires overcoming various challenges, including adapting financial strategies and addressing infrastructure needs. As MR continues to evolve, it is poised to play a pivotal role in shaping the future of the retail sector. The study underscores the need for ongoing research to fully understand and leverage the potential of MR in retail.

Keywords: Mixed Reality; Retail Sector; Customer Engagement; Virtual Reality; United States

1. Introduction

1.1. The Advent of Mixed Reality in Retail: Transforming Shopping Experiences

The retail landscape has undergone a significant transformation with the advent of mixed reality (MR), reshaping the traditional shopping experience into an immersive and interactive journey. Mixed reality, blending the physical and digital worlds, has emerged as a pivotal technology in retail, offering novel ways to engage customers and enhance their shopping experiences.

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Jain et al. (2021) explored the integration of mixed reality in omnichannel retail through the development of a mixed reality-based digital shopping assistant. This innovation aimed to provide a holistic shopping experience by incorporating elements such as product information, reviews, recommendations, and a purchase option. Their study, utilizing head-mounted displays like Microsoft HoloLens, revealed a positive customer attitude towards MR technology. It highlighted the significant impact of MR on various aspects of the shopping experience, including perceived convenience, service quality, and the overall attitude towards the retailer. The findings underscored the potential of MR in revolutionizing customer interactions in retail settings (Jain, Schweiß, Bender, & Werth, Year Unknown).

In a similar vein, Meegahapola and Perera (2017) demonstrated the effectiveness of MR in enhancing in-store shopping experiences through a smartphone-based mixed reality application. This application, designed to gamify the shopping process, allowed retail owners to create immersive experiences with ease. The deployment of this technology in real-world retail environments, such as Media-Markt outlets in Munich and Singer Mega showrooms in Sri Lanka, resulted in positive customer feedback and a marked improvement in the shopping experience. A significant majority of users acknowledged that the application influenced their buying decisions, highlighting the persuasive power of MR in retail (Meegahapola & Perera, 2017).

Gil-López et al. (2023) further expanded on the effectiveness of MR in retail by examining its impact from a vividness and interaction perspective. Their study compared the implicit reactions of shoppers interacting with products with and without MR glasses. The results indicated that MR technology altered the patterns of interaction, such as frequency and duration, and influenced decision times, particularly in utilitarian purchases. The study also found that the perceived hedonic and utilitarian values of the shopping experience were heightened when MR was employed. This enhancement in the shopping experience translated into positive future purchase intentions and an improved emotional state among consumers (Gil-López, et al., 2023).

The advent of mixed reality in retail has thus marked a paradigm shift in how consumers interact with products and make purchasing decisions. The immersive and interactive nature of MR technology not only enriches the shopping experience but also fosters a deeper connection between consumers and brands. As these studies illustrate, MR has the potential to transform retail spaces into dynamic, engaging environments, offering personalized and memorable shopping experiences. This technological evolution signifies a new era in retail, where the blending of physical and digital realms opens up limitless possibilities for customer engagement and satisfaction.

1.2. Understanding Mixed Reality in the Retail Sector

The concept of Mixed Reality (MR) in the retail sector encompasses a broad spectrum of technologies and applications, blending the physical and digital realms to create immersive shopping experiences. Understanding the scope and definition of MR is crucial for comprehending its transformative impact on the retail industry.

Martins et al. (2022) provide insights into the realm of Situated Visualization (SV), a concept closely related to MR. SV refers to visualizations that adapt their appearance based on the physical context in which they are displayed. This adaptability is particularly relevant in retail, where contextual information can significantly enhance the shopping experience. Augmented and Mixed Reality technologies, by displaying additional data about the real-world context, play a pivotal role in this scenario. The study by Martins et al. emphasizes the need for a comprehensive understanding of MR and its applications, including its ability to support decision-making in retail environments through context-driven visualization techniques (Martins, et al., 2022).

Chytas et al. (2022) delve into the definitions of MR and Augmented Reality (AR), highlighting the nuances that distinguish these technologies. While AR is often described as a technology that overlays digital objects onto the real world, MR goes a step further by allowing interaction with these digital elements. This distinction is critical in the retail context, where the ability to interact with virtual products can significantly enhance the customer experience. The study underscores the importance of clearly defining these technologies to fully appreciate their potential in retail applications. It also points out the heterogeneity in definitions, which can lead to confusion and underestimation of the technology's capabilities in enhancing retail experiences (Chytas et al., 2022).

Di Capua et al. (2011) address the development and rapid prototyping of mobile applications for augmented reality interactions, a key component of MR in retail. Their work underscores the importance of developing tools that simplify the business development process and support the analysis of the quality of human interactions in AR environments. This aspect is particularly relevant in retail, where the quality of customer interaction with MR applications can make or break the shopping experience. The study highlights the need for user-friendly, efficient, and effective MR

applications in retail, which can be rapidly prototyped and deployed to enhance customer engagement (Di Capua et al., 2011).

Therefore, understanding the scope and definition of Mixed Reality in the retail sector involves recognizing its capabilities beyond mere digital overlay. MR in retail is about creating interactive, context-aware experiences that merge the physical and digital worlds. This technology has the potential to revolutionize the retail landscape by offering personalized, immersive, and engaging shopping experiences. As the retail industry continues to evolve, MR stands out as a key technology driving this transformation, promising a future where shopping is not just a transaction but an immersive journey into the realms of digital innovation.

1.3. Historical Progression: From Conventional Retail to Immersive Technologies

The evolution of retail from conventional methods to the adoption of immersive technologies like Mixed Reality (MR) represents a significant shift in how consumers interact with products and services. This progression is marked by technological advancements that have reshaped the retail landscape, offering new opportunities for customer engagement and business growth.

Fernandes and Morais (2021) delve into the technological advancements in fashion retail, highlighting the transition from traditional retail practices to more innovative solutions like Smart Fitting Rooms (SFR) and Interactive Mirrors (IM). These technologies, initially perceived as futuristic concepts, faced challenges in early adoption due to limitations in business models and technological capabilities at the time. However, the emergence of Augmented Reality (AR), Virtual Reality (VR), and Mixed-Reality (MR), coupled with advancements in smartphone technology, has revitalized these solutions, offering new possibilities for fashion retail. This shift underscores the evolving nature of retail, where technology plays a pivotal role in enhancing the shopping experience and meeting the changing demands of consumers (Fernandes & Morais, 2021).

Dzardanova and Kasapakis (2022) provide a historical account of the evolution of Virtual Reality (VR), a key component of immersive retail technologies. Their study traces VR's journey from its early conceptualization to its current status as a mainstream technology. This progression highlights the gradual development of VR and its increasing integration into various sectors, including retail. The study emphasizes the continuous advancements in VR technology, which have enabled retailers to create more engaging and interactive shopping experiences. This historical perspective on VR illustrates the technological milestones that have influenced the retail sector, leading to the adoption of immersive technologies that enhance customer engagement and satisfaction (Dzardanova & Kasapakis, 2022).

Woods, Doherty, and Stephens (2021) explore the implications of technology-driven changes in the retail sector, particularly in the context of higher education. Their research highlights the impact of Industry 4.0 technologies, such as big data, the Internet of Things (IoT), blockchain, automation, robotics, artificial intelligence, and virtual reality, on the retail industry. The study reveals that the skills required in the retail sector are evolving, necessitating a combination of human, digital, and traditional skills. This evolution reflects the broader trend in retail, where technological advancements are not only changing the way products are sold and marketed but also transforming the skill sets required to thrive in this dynamic industry. The findings from this study underscore the need for continuous learning and adaptation in the face of technological advancements in retail (Woods, Doherty, & Stephens, 2021).

The historical progression from conventional retail to immersive technologies is marked by significant technological advancements that have transformed the shopping experience. From the early challenges faced by innovative retail technologies to their current widespread adoption, this evolution reflects the changing dynamics of consumer behavior and the retail industry's response to these changes. As immersive technologies continue to evolve, they offer new opportunities for retailers to engage with customers in more meaningful and interactive ways, paving the way for a future where technology and retail are inextricably linked.

1.4. Research Gap

Despite the growing interest and application of Mixed Reality (MR) in the retail sector, there remains a significant research gap in comprehensively understanding its multifaceted impact, particularly in the U.S. retail context. Current literature predominantly focuses on the technological aspects of MR, such as its development and technical capabilities, while less attention is given to the holistic integration of MR within the retail environment, including its economic implications, customer engagement strategies, and regulatory challenges. Furthermore, most existing studies offer a fragmented view of MR's application in retail, concentrating either on specific case studies or on theoretical models without adequately bridging the gap between these approaches. There is a lack of comprehensive research that synthesizes these individual perspectives to provide a full picture of how MR technologies are being integrated into the

retail sector, how they are reshaping customer experiences, and what future trends are emerging. Additionally, while there is some understanding of the potential of MR in retail, there is a scarcity of empirical research on the actual economic impact of MR technologies in the retail sector. This includes a gap in knowledge regarding cost-benefit analysis for retailers, market growth potential, and the financial opportunities MR presents. Moreover, the regulatory and standardization aspects of MR in retail are not sufficiently explored. As MR technology continues to evolve and become more prevalent in retail settings, understanding the regulatory landscape and the need for standardization becomes increasingly important for its successful implementation.

1.5. Aims and Objectives of the Study

The aim of this research is to comprehensively analyze the impact and potential of Mixed Reality (MR) technologies in the U.S. retail sector, focusing on how these technologies are transforming shopping experiences, enhancing customer engagement, and influencing the economic landscape of retail.

The objectives are;

- To explore the evolution and current state of mixed reality in retail.
- To assess the impact of mixed reality on customer shopping experiences.
- To investigate strategies for customer engagement through mixed reality.

2. Methodology

2.1. Data Gathering: Identifying Relevant Sources

The primary data sources for this study were academic journals, conference proceedings, and industry reports focusing on Mixed Reality (MR) in retail. These sources were accessed through various academic databases and search engines, including Google Scholar, PubMed, IEEE Xplore, and specific databases relevant to technology and retail studies. Additionally, reports from market research firms and case studies from retail companies implementing MR technologies were also considered to provide practical insights into the current state and future trends of MR in retail.

2.2. Literature Search Strategy

The search strategy involved a combination of keyword searches and manual screening. Keywords related to "Mixed Reality," "Retail," "Customer Engagement," "Economic Implications," and "Technological Advancements" were used. Boolean operators (AND, OR) were employed to refine the search. For instance, searches like "Mixed Reality AND Retail," "Mixed Reality AND Customer Engagement," and "Economic Implications of Mixed Reality in Retail" were conducted. The search was not limited to a specific time frame to capture the full scope of the development and impact of mixed reality in retail.

2.3. Inclusion and Exclusion Criteria

2.3.1. Inclusion criteria

- Peer-reviewed articles focusing on MR applications in retail.
- Studies discussing the economic, technological, and customer engagement aspects of MR in retail.
- Reports and case studies from credible sources detailing practical implementations of MR in retail.

2.3.2. Exclusion criteria

- Non-peer-reviewed articles and opinion pieces without empirical data.
- Studies focusing on MR applications outside the retail sector.
- Outdated reports that do not reflect the current state of MR technology.

2.4. Selection Criteria

The selection of literature was based on relevance to the study's objectives, the credibility of the source, and the comprehensiveness of the information provided. Priority was given to recent studies to ensure the data reflected the latest trends and advancements in MR technology. Additionally, studies that provided unique insights into the application of MR in retail, including case studies and industry reports, were selected to offer a balanced view between theoretical research and practical.

2.5. Data Analysis

Data analysis involved a thematic approach where information from selected sources was categorized based on recurring themes such as technological advancements, customer engagement strategies, economic implications, and regulatory aspects. This thematic analysis helped in identifying patterns and trends in the application of MR in retail. The findings from the literature were then synthesized to provide a comprehensive understanding of the current state and future prospects of MR in retail, including its challenges, opportunities, and potential impact on the retail sector.

3. Exploring Mixed Reality in Retail

3.1. Fundamentals of Mixed Reality: Theoretical and Practical Aspects

Mixed Reality (MR) has emerged as a transformative technology in the retail sector, blending the physical and digital worlds to create immersive shopping experiences. Understanding the theoretical and practical aspects of MR is crucial for its effective implementation in retail.

Pamparău and Vatavu (2020) emphasize the need for a comprehensive research agenda focused on designing user experiences in Augmented and Mixed Reality. Their position paper highlights the overlooked theoretical work and practical opportunities in MR, particularly in the context of user experience. Despite significant innovations in MR technologies, the design of user experiences in MR environments has been relatively neglected, with existing knowledge primarily covering usability aspects. The authors advocate for establishing theoretical foundations for MR user experiences, proposing directions for scientific research in this area. This focus on user experience is critical in retail, where customer engagement and satisfaction are paramount (Pamparău & Vatavu, 2020).

Jain and Werth (2019) provide an extensive review of the current state of MR technology in digital retail. Their literature review explores the evolution of retail from traditional in-store setups to digital and omnichannel retail, emphasizing the role of MR in this transition. The paper identifies research gaps and proposes frameworks and guidelines for the optimal application of MR in retail. This includes understanding how MR can enhance user experiences and the practical considerations for its deployment in retail environments. The study underscores the importance of MR in creating engaging and interactive shopping experiences, highlighting its potential to revolutionize the retail sector (Jain & Werth, 2019).

Bae et al. (2020) investigate the influence of MR on customer satisfaction and brand loyalty from a brand equity perspective. Their study, conducted in a cultural and artistic visitor attraction, examines how the characteristics of MR, such as interactivity and vividness, affect visitors' experiences and, consequently, brand loyalty. The findings suggest that MR not only enhances the affective aspects of the experience, such as perceived immersion and enjoyment, but also positively impacts brand awareness, association, and loyalty. This research provides valuable insights into the practical implications of MR in retail, demonstrating its potential to create satisfying experiences that foster brand loyalty (Bae et al., 2020).

The fundamentals of MR in retail encompass both theoretical and practical aspects. The theoretical foundations focus on designing user experiences that are engaging and satisfying, while the practical aspects involve the application of MR technology to enhance customer interactions and brand loyalty. As MR continues to evolve, its role in retail becomes increasingly significant, offering new opportunities for creating immersive and memorable shopping experiences. Understanding these fundamentals is essential for retailers looking to leverage MR technology to its fullest potential.

3.2. Immersive Shopping Experiences: Case Studies and Models

The integration of Mixed Reality (MR) in retail has led to the development of immersive shopping experiences, transforming how consumers interact with products and brands. Ricci et al. (2023) conducted a study comparing Immersive Virtual Reality (IVR) and Desktop Virtual Reality (DVR) in virtual fashion stores. Their research involved a within-subject experiment with 60 participants who engaged in a simulated shopping experience in both IVR and DVR setups. The IVR experience utilized a Head-Mounted Display (HMD) and controllers, while the DVR experience was conducted using a desktop computer setup. The study found that participants experienced higher levels of hedonism and utilitarianism in the IVR shop compared to DVR. Additionally, the time duration of the shopping experience was longer in IVR, indicating that users were more immersed and enjoyed the experience for an extended period. This research highlights the potential of IVR in enhancing the shopping experience in the fashion industry, suggesting novel shopping patterns that could emerge from the use of such technology (Ricci, Evangelista, Di Roma, & Fiorentino, 2023).

Alcántara and Alcántara (2022) explored the future of shopping through the lens of the Metaverse and immersive experiences. Their case study, titled "hibe," focused on changing consumer mindsets by providing meaningful digital/physical shopping experiences, particularly for Gen Z. The study addressed how to develop technological solutions that blend the physical and digital realms, offering immersive experiences that are both meaningful and safe. This approach aimed to cater to the unique needs, limitations, and skills of Gen Z, a generation that values physical interaction and experiences as much as digital ones. The "hibe" case study represents a forward-thinking model in retail, leveraging the Metaverse to create immersive experiences that resonate with younger consumers (Alcántara & Alcántara, 2022).

Hwangbo, Kim, and Cha (2017) presented a case study on the use of smart stores for persuasive marketing and immersive customer experiences in a Korean apparel enterprise. The study explored how new technologies, such as sensors, indoor positioning, augmented reality, and interactive systems, can support offline retailers in improving operational efficiency and customer experience. The concept of the "smart store" was employed to indicate retail stores equipped with these new technologies and modern marketing concepts. The case study demonstrated how the smart store concept could be applied in real-world retail environments, offering insights into the potential applications and benefits of such technologies in enhancing customer experiences and business operations (Hwangbo, Kim, & Cha, 2017).

These case studies and models demonstrate the diverse applications and impacts of MR and related technologies in retail. From enhancing the shopping experience in virtual fashion stores to integrating immersive experiences in the Metaverse, and employing smart store concepts for persuasive marketing, these examples illustrate the transformative potential of MR in retail. As these technologies continue to evolve, they offer retailers new opportunities to engage with customers in innovative and immersive ways, shaping the future of the shopping experience.

3.3. Customer Engagement through Mixed Reality: Strategies and Outcomes

The integration of Mixed Reality (MR) in retail has opened new avenues for customer engagement, offering immersive experiences that go beyond traditional shopping methods. Kathikeyan et al. (2022) investigated the impact of combining Artificial Intelligence (AI) with MR technology for interactive displays in a smart retail environment. Their study focused on a 17 million AI-embedded MR exhibit in a shopping and entertainment complex. The research demonstrated that the integration of AI with MR, particularly in voice synthesis and recognition using machine learning, significantly enhanced MR enjoyment, spatial immersion, and consumers' perceptions of unique experiences. These elements collectively stimulated consumer interest, elicited favorable reactions, and even influenced purchasing decisions and word-of-mouth promotion. This study highlights the potential of interactive AI and MR technology in creating engaging retail experiences that not only attract customers but also encourage them to engage more deeply with the brand (Kathikeyan et al., 2022).

Richards (2023) presented a case study on the use of HoloLens MR technology in human anatomy laboratories for osteopathic medical students. While this study is set in an educational context, it provides valuable insights into the effectiveness of MR in engaging users. The study employed Gagne's model for instructional design and team-based learning to create an active learning model targeting behavioral, emotional, and cognitive dimensions of student engagement. This model can be adapted for retail, where engaging customers on multiple levels – behaviorally, emotionally, and cognitively – is crucial. The findings suggest that MR technology, when used effectively, can significantly enhance engagement by providing immersive, interactive experiences that resonate with users on various levels (Richards, 2023).

Boletsis and Karahasanovic (2020) explored the practices of Augmented Reality (AR) and Virtual Reality (VR) in retail. Their literature review documented various AR and VR applications in retail, identifying key practices such as branding and marketing, sales channel enhancement, after-sale customer service, virtual try-on, and customer-as-designer. The study observed that AR and VR technologies are primarily used for customer-related innovation, with branding and marketing being dominant practices. AR, in particular, was found to be highly practical in retail environments, fitting well with the purchase journey and workflow management. In contrast, VR, though more challenging to implement, can create strong emotional engagement due to its high immersion level, making it a useful tool for branding and training. This research underscores the diverse applications of immersive technologies in retail and their ability to supplement each other in creating innovative customer engagement strategies (Boletsis & Karahasanovic, 2020).

Therefore, MR technologies, including AR and VR, offer innovative ways to engage customers in the retail sector. From enhancing the shopping experience with interactive AI and immersive displays to providing engaging and educational experiences, MR technologies are reshaping the landscape of customer engagement in retail. These technologies not only attract and retain customers but also foster deeper connections between consumers and brands, leading to positive

outcomes such as increased sales and brand loyalty. As MR continues to evolve, its role in customer engagement strategies in retail is likely to become even more significant.

3.4. Milestones in Mixed Reality Retail: A Historical Perspective

The evolution of Mixed Reality (MR) in retail represents a series of significant milestones that have transformed the shopping experience. Gil-López et al. (2023) conducted a study to evaluate the effectiveness of MR technology in retail from a vividness and interaction perspective. Their research compared the implicit reactions of shoppers interacting with products with and without MR glasses. The study revealed that MR technology significantly influenced the patterns of interaction, such as frequency and duration with products, and impacted decision times related to utilitarian purchases. Participants using MR glasses reported higher perceived hedonic and utilitarian values of the shopping experience, which also affected their future purchase intentions and emotional state. This research highlights the relative advantage of MR in enhancing the retail shopping experience, marking a significant milestone in the integration of MR in retail (Gil-López, et al., 2023).

Goyal et al. (2023) explored the future perspectives of MR in the context of financial services, providing insights into the broader implications of MR in the retail sector. Their study focused on the evolving trends towards emerging technologies like AR and VR in retail, particularly in the fashion industry. The research underscored the potential of MR to revolutionize the retail industry by enhancing customer experiences and aiding consumers in their purchasing decisions. This study represents a milestone in understanding the expanding role of MR in retail, beyond just the shopping experience, to include aspects like financial services and consumer decision-making processes (Goyal et al., 2023).

Meegahapola and Perera (2017) presented a case study on enhancing the in-store shopping experience through a smartphone-based MR application. This application allowed retail owners to create MR-based experiences with just a few clicks, offering customers a unique and interactive shopping experience. The use of this MR application in real-world environments, such as Media-Markt outlets in Munich and Singer Mega showrooms in Sri Lanka, resulted in positive customer feedback and improved overall shopping experiences. A significant 82.1% of users agreed that the application influenced their buying decisions, marking a key milestone in the practical application of MR in retail environments (Meegahapola & Perera, 2017).

These milestones in MR retail highlight the technology's evolution from a novel concept to a practical tool enhancing customer experiences. From influencing shopping behaviors and decision-making processes to revolutionizing in-store experiences, MR has proven to be an effective tool in retail. These developments not only reflect the technological advancements in MR but also underscore the changing dynamics of consumer behavior and the retail industry's response to these changes. As MR continues to evolve, its role in shaping the future of retail is likely to grow, offering new opportunities for engaging customers and transforming the shopping experience.

3.5. Current Innovations and Trends in Mixed Reality Shopping

The retail sector is witnessing a significant transformation with the advent of Mixed Reality (MR) technologies. Jain and Werth (2019) conducted a comprehensive literature review to assess the current state of MR technology in digital retail. Their study highlighted the evolution of retail from traditional physical in-store setups to digital and omnichannel retail, emphasizing the role of MR in this transition. The integration of MR technologies in retail has led to the development of immersive shopping experiences, enhancing customer engagement and satisfaction. The study also identified research gaps and proposed frameworks for the efficient development and deployment of MR in omnichannel retail. This research underscores the growing importance of MR in retail, offering insights into how MR can optimize user experiences in the digital retail space (Jain & Werth, 2019).

Moorhouse et al. (2018) reviewed technological innovations transforming the consumer retail experience. Their study focused on the strategic implementation of Augmented Reality (AR) and Virtual Reality (VR) technologies in retail. The integration of these technologies has led to a revolutionary change in consumer shopping and buying behavior, driving the decline in traditional brick-and-mortar footfall. The study highlighted how emergent technologies like AR and VR are being used to promote the experiential benefits of in-store environments, thereby transforming the consumer experience in various ways. This research provides valuable insights into the future implications of AR and VR technologies in retail, suggesting that these technologies will continue to play a significant role in shaping consumer experiences (Moorhouse et al., 2018).

Rokhsaritalemi et al. (2020) reviewed current trends, challenges, and prospects in MR. Their study presented a comprehensive framework for developing MR applications, addressing system components, architectural issues,

application execution, and user interface layers. The review highlighted the increasing level of user interaction as a key issue in designing MR applications. The findings of this study are particularly relevant to retail, as MR applications can serve as decision-making tools in shopping, enhancing customer engagement and experience. The study also discussed the practical issues for stakeholders in considering different domains of MR, indicating the broad applicability of MR in various retail contexts (Rokhsaritalemi et al., 2020).

Current innovations and trends in MR shopping indicate a shift towards more immersive and interactive retail experiences. The integration of AR and VR technologies in retail is not only enhancing customer engagement but also revolutionizing the way consumers shop and interact with products. As MR technologies continue to evolve, they are expected to bring more innovative solutions to the retail sector, further transforming the shopping experience and offering new opportunities for retailers to engage with their customers.

3.6. Future Directions in Mixed Reality Retail

The retail sector is on the cusp of a transformative era with the integration of Mixed Reality (MR) technologies. The study of Goyal et al. (2023) examined the future perspectives of MR in the context of Financial Services 4.0, providing a broader view of the potential impact of MR in retail. Their research highlighted the increasing relevance of AR and VR in the retail sector, particularly in clothing. The study underscored the shift towards emerging technologies and how they are shaping consumer behaviors and preferences. The findings suggest that the integration of MR technologies in retail is not only about enhancing the shopping experience but also about redefining the entire consumer journey, including aspects like financial transactions and decision-making processes. This research indicates that MR will play a crucial role in the future of retail, offering innovative solutions that cater to the evolving needs of consumers (Goyal et al., 2023).

Gil-López et al. (2023) explored the effectiveness of MR technology in retail from a vividness and interaction perspective. Their study revealed that MR technologies significantly influence consumer behavior, particularly in terms of interaction patterns and decision-making processes. The research highlighted the potential of MR to enhance the shopping experience by providing immersive and interactive environments. The findings suggest that future MR applications in retail will focus on creating more vivid and engaging experiences, leveraging the technology to influence consumer behavior and enhance the overall shopping experience (Gil-López, Guixeres, Marín-Morales, Torrecilla, Williams, & Alcañiz, 2023).

Stenlin (2022) investigated the future potential of retail virtual stores, focusing on the impact of head-mounted displays (HMDs) and VR on the retail sector. The study examined how VR could improve the shopping experience at every stage of the customer journey. The research included interactions with industry specialists and average customers, providing a comprehensive view of the future trends in online retail. The findings indicate that VR and MR technologies will continue to gain momentum, transforming the way consumers shop online. The study suggests that future retail virtual stores will offer more immersive and interactive experiences, potentially changing the landscape of online shopping (Stenlin, 2022).

The future directions in MR retail point towards a more immersive, interactive, and comprehensive shopping experience. The integration of MR technologies is expected to redefine the retail sector, influencing consumer behavior, enhancing the shopping experience, and offering innovative solutions that cater to the digital natives of today. As MR technologies continue to evolve, they are poised to play a pivotal role in shaping the future of retail, offering new opportunities for retailers to engage with their customers in more meaningful ways.

3.6.1. Enhancing Customer Interaction and Personalization

The integration of Mixed Reality (MR) in retail has opened new avenues for enhancing customer interaction and personalization. Jain et al. (2021) investigated the use of MR in omnichannel retail, focusing on a mixed reality-based digital shopping assistant designed to provide a holistic shopping experience. Their study utilized design science research methodology to develop a system that included product information, reviews, recommendations, and a purchase option. The research involved evaluating the system with two different head-mounted displays, Microsoft HoloLens and HoloLens 2, and 29 participants. The results showed a positive customer attitude towards the technology, with significant effects on technology adoption, enjoyment, and security beliefs. The study highlighted the potential of MR to enhance customer interaction and personalization in retail, particularly in terms of perceived convenience, service quality, and overall attitude towards the retailer (Jain et al., 2021).

Jiang et al. (2021) explored the enhancement of customer experience in the retail industry through mixed reality. Their research focused on customization in MR, allowing customers to choose and customize products with their images and

labels in a virtual reality environment. The study proposed a real-time 3D logo mapping framework for converting 3D logo mesh from specified images and fitting it to 3D product models. This method preserved the visual quality and details of 3D product models while allowing for real-time customization by customers. The results demonstrated the effectiveness of this approach in producing accurately and quickly customized logos on 3D product models, indicating the potential of MR for personalization in retail (Jiang, Tran, Williams, Palmer, Simson, Benson, Christopher, & Christopher, 2021).

Gil-López et al. (2023) examined the effectiveness of MR technology in retail from a vividness and interaction perspective. Their study analyzed how consumers respond to MR features and which elements of the MR-based experience impact behavior. The research revealed that participants wearing MR glasses exhibited different patterns of interaction with products, affecting their decision times and purchase types. The findings showed that the perceived hedonic and utilitarian values of the purchase experience were higher when MR was used. This study underscores the role of MR in enhancing customer interaction and personalization in retail, particularly in terms of creating vivid and engaging experiences that influence consumer behavior (Gil-López et al., 2023).

MR technologies are significantly enhancing customer interaction and personalization in retail. From digital shopping assistants to real-time customization and vivid, interactive experiences, MR is transforming the way customers engage with products and brands. As MR continues to evolve, it offers new opportunities for retailers to create more personalized and engaging shopping experiences, catering to the individual needs and preferences of consumers.

3.6.2. Integration and Evolution of Retail Spaces

The integration and evolution of retail spaces in Mixed Reality (MR) represent a significant shift in the retail industry, offering new dimensions of customer experience and interaction. Jain and Werth (2019) provided a comprehensive overview of the current state of MR technology in digital retail. Their literature review highlighted the transition from traditional physical in-store setups to digital and omnichannel retail, emphasizing the role of MR in this evolution. The study underscored the importance of developing appropriate frameworks and guidelines for the efficient deployment of MR in omnichannel retail to optimize user experiences. This research indicates that MR is not just an add-on technology but a fundamental component that is reshaping retail spaces, offering immersive environments that blend the physical and digital worlds (Jain & Werth, 2019).

Gil-López et al. (2023) explored the effectiveness of MR technology in retail from a vividness and interaction perspective. Their study analyzed consumer behavior in response to MR features, such as vividness and novelty, and how these elements impact shopping practices. The findings revealed that MR technology significantly alters consumer interaction patterns, offering a more engaging and immersive shopping experience. This research highlights the potential of MR to transform retail spaces into dynamic environments where physical reality and digital content are seamlessly integrated, enhancing the overall shopping experience (Gil-López et al., 2023).

Zhang et al. (2021) investigated the application of immersive media in new retail cyberspace, focusing on the impact of VR and AR technologies. Their study discussed how these technologies, especially in the context of the COVID-19 pandemic, have accelerated the growth of the new retail industry. The research emphasized the role of immersive media in building a new paradigm for commercial information dissemination, suggesting that MR technologies are crucial in the economic growth of coastal cities. This study illustrates how MR is not only transforming retail spaces but also playing a significant role in the broader economic landscape, particularly in digital media and multi-sensory interaction (Zhang et al., 2021).

The integration and evolution of retail spaces in MR are marked by the seamless blending of physical and digital elements, creating immersive and interactive environments. These developments are reshaping the retail industry, offering new ways for consumers to experience and interact with products. As MR technologies continue to advance, they are expected to further revolutionize retail spaces, leading to more innovative and engaging shopping experiences.

4. Discussion of Findings

4.1. Impact Assessment of Mixed Reality in Retail

The integration of Mixed Reality (MR) and Extended Reality (XR) technologies in retail has been a subject of significant interest, with implications for transforming the retail landscape. The study of Alcaniz et al. (2019) delves into how XR technologies, encompassing Virtual Reality (VR), Augmented Reality (AR), and MR, are influencing the retail industry. The research adopts a multifaceted qualitative approach, including literature reviews, retail conferences, and interviews

with industry experts. The findings indicate that XR technologies are critical contributors to company success in retail. They are currently utilized to enhance customer experience, improve training, conduct consumer behavioral analyses, and develop prototyping for increased efficiency in product merchandising, packaging, and branding. However, the study also notes that successful implementation of these technologies requires an understanding of each technology's specific affordances for effective integration within different areas of the retail supply chain. This research underscores the transformative potential of XR technologies in retail, suggesting a future where these technologies become a mainstream necessity for retail success (Alcaniz et al., 2019).

Móga et al. (2021) examined the use of AR and MR technologies in a different context, focusing on their support in digital surgery. While this study is set in the medical domain, it provides insights into the broader implications of AR and MR technologies. The systematic review collected and compared outcomes of recent articles on AR and MR in surgical practice, highlighting the usability of heads-up holographic technology. The findings from this study can be extrapolated to retail, where similar technologies can be used for enhancing customer experiences, training, and operational efficiency. The research indicates that as technological improvements continue, standards are required to guide future research and applications of AR/MR, a notion that is equally applicable in the retail sector (Móga et al., 2021).

The impact of MR and XR technologies in retail is profound, offering enhanced customer experiences, operational efficiencies, and new ways of consumer engagement. These technologies are reshaping the retail landscape, with their successful implementation dependent on a nuanced understanding of their specific affordances and applications. As these technologies continue to evolve, they are expected to become integral to the retail industry's future success.

4.1.1. Technological Advancements and Their Retail Implications

The retail sector is undergoing a significant transformation due to the advent of Mixed Reality (MR) and Extended Reality (XR) technologies. The study of Jain et al. (2021) investigated the use of MR in omnichannel retail, focusing on a mixed reality-based digital shopping assistant designed to provide a holistic shopping experience. Their study utilized design science research methodology to develop a system that included product information, reviews, recommendations, and a purchase option. The research involved evaluating the system with two different head-mounted displays, Microsoft HoloLens and HoloLens 2, and 29 participants. The results showed a positive customer attitude towards the technology, with significant effects on technology adoption, enjoyment, and security beliefs. The study highlighted the potential of MR to enhance customer interaction and personalization in retail, particularly in terms of perceived convenience, service quality, and overall attitude towards the retailer (Jain, et al., 2021).

Wu and Kim (2022) explored users' perceptions of technological features in AR and VR in fashion retailing. Their study presented a qualitative content analysis of focus group interviews, analyzing users' perceptions of AR and VR technological features. The findings indicated that users' perception of AR technological features consisted of dimensions such as augmentation, user control, vividness, responsiveness, and simplicity. In contrast, users' perception of VR technological features included telepresence, simulator sickness, visual discomfort, and user control. The study provided practical implications for the application of mixed reality technology in fashion venues, suggesting that AR technology should focus on control and simplicity, while VR should leverage immersive experiences facilitated by telepresence. This research offers valuable insights into the application of AR and VR in fashion retailing, helping marketers develop new solutions for integrating these technologies (Wu & Kim, 2022).

In summary, the technological advancements in MR and XR are reshaping the retail industry, offering enhanced customer experiences, operational efficiencies, and new ways of consumer engagement. These technologies are transforming the retail landscape, with their successful implementation dependent on a nuanced understanding of their specific affordances and applications. As these technologies continue to evolve, they are expected to become integral to the retail industry's future success.

4.1.2. Addressing Challenges in Current Mixed Reality Retail Models

The integration of Mixed Reality (MR) in retail has brought about innovative changes, but it also presents unique challenges that need to be addressed for its effective implementation. Jain and Werth (2019) conducted a comprehensive literature review to assess the current state of MR technology in digital retail. Their study highlighted the evolution of retail from traditional physical in-store setups to digital and omnichannel retail, emphasizing the role of MR in this transition. The research underscored the importance of developing appropriate frameworks and guidelines for the efficient deployment of MR in omnichannel retail to optimize user experiences. However, the study also identified significant challenges, including the need for better integration of MR technologies into existing retail models and the development of more user-friendly interfaces. Addressing these challenges is crucial for the successful

implementation of MR in retail, as it requires a nuanced understanding of both technology and consumer behavior (Jain & Werth, 2019).

Jiang et al. (2021) explored the enhancement of customer experience in the retail industry through mixed reality. Their research focused on customization in MR, allowing customers to choose and customize products with their images and labels in a virtual reality environment. However, the study highlighted challenges such as the labor-intensive and time-consuming nature of existing asset creation pipelines for displaying images and labels on 3D product models. To address these challenges, the researchers proposed a real-time 3D logo mapping framework that could quickly and accurately customize logos on 3D product models. This approach demonstrates how technological advancements can overcome some of the practical challenges in implementing MR in retail (Jiang et al., 2021).

Fanani et al. (2021) discussed the challenges in developing VR, AR, and MR applications, with implications for the retail sector. The study proposed a model to support the development of 3D-based applications involving these technologies. One of the key challenges identified was the lack of planning in research and development, which often leads to suboptimal utilization of these technologies. The proposed model aimed to provide a practical and effective way to develop applications by addressing these challenges. This research is relevant to the retail sector as it provides insights into how to effectively implement MR technologies by overcoming common developmental hurdles (Fanani et al., 2021).

While MR technologies offer significant potential to transform the retail sector, they also present challenges that need to be addressed. These include the integration of MR into existing retail models, the development of user-friendly interfaces, and overcoming practical hurdles in technology implementation. Addressing these challenges is crucial for leveraging the full potential of MR in retail, ensuring that these technologies not only enhance the customer experience but also align with the operational and strategic goals of retail businesses.

4.1.3. Trends in Customer Engagement Techniques

The retail sector is increasingly leveraging Mixed Reality (MR) and related technologies to enhance customer engagement. Kathikeyan et al. (2022) investigated the integration of Artificial Intelligence (AI) with MR technology for interactive displays in retail environments. Their study focused on a 17 million AI-embedded MR exhibit in a shopping and entertainment complex. The research showed that the combination of AI and MR, particularly in voice synthesis and recognition using machine learning, significantly enhanced MR enjoyment, spatial immersion, and consumers' perceptions of unique experiences. These elements collectively stimulated consumer interest and elicited favorable reactions, including the desire to make a purchase and the inclination to share the experience with others. This study demonstrates the potential of interactive AI and MR technology in creating engaging retail experiences that captivate consumers and encourage deeper engagement (Kathikeyan et al., 2022).

Bae and Deborah (2020) discussed the omnichannel customer experience and technological evolution in retail. Their research highlighted how online shopping and technological advancements are reshaping the dynamics of omnichannel retail. The study emphasized the need for retail companies to be equipped with advanced technologies and stay informed of evolving industry and consumer trends in this new retail environment. The integration of technologies like MR in retail is not just about enhancing the shopping experience but also about adapting to the changing landscape of consumer behavior and preferences. This research suggests that MR and related technologies are crucial for retail businesses to engage customers effectively in an increasingly digital world (Bae & Deborah, 2020).

Zaveri and Amin (2019) explored the future of marketing trends with a focus on Augmented Reality (AR) and Virtual Reality (VR). Their study discussed how cognitive technology, or AI, is being used in conjunction with AR and VR to revolutionize marketing in the digital era. The research highlighted the importance of understanding consumer behavior, preferences, and search history tracking in the context of digital marketing. The study proposed that AR Experiential Marketing (AREM) is beneficial for enhancing customer satisfaction by using knowledge, while VR focuses on knowledge and emotional engagement with various techniques. This research underscores the evolving role of AR and VR in retail marketing, suggesting that these technologies are key mechanisms for companies in the 21st century to engage customers effectively (Zaveri & Amin, 2019).

The trends in customer engagement techniques in mixed reality retail are characterized by the integration of AI with MR and VR technologies to create immersive and interactive experiences. These technologies are transforming the retail landscape, offering novel ways to engage customers and enhance their shopping experiences. As MR continues to evolve, it is expected to play a pivotal role in shaping the future of retail marketing and customer engagement.

4.1.4. Future Projections for Mixed Reality in Retail

The retail industry is poised for significant transformations with the advancement of Mixed Reality (MR) technologies. Goyal et al. (2023) examined the future perspectives of MR in the context of Financial Services 4.0, providing insights into the broader implications of MR in retail. Their research highlighted the increasing relevance of AR and VR in the retail sector, particularly in clothing. The study underscored the shift towards emerging technologies and how they are shaping consumer behaviors and preferences. The findings suggest that the integration of MR technologies in retail is not only about enhancing the shopping experience but also about redefining the entire consumer journey, including aspects like financial transactions and decision-making processes. This research indicates that MR will play a crucial role in the future of retail, offering innovative solutions that cater to the evolving needs of consumers (Goyal et al. 2023).

Stenlin (2022) investigated the future potential of retail virtual stores, focusing on the impact of head-mounted displays (HMDs) and VR on the retail sector. The study examined how VR could improve the shopping experience at every stage of the customer journey. The research included interactions with industry specialists and average customers, providing a comprehensive view of the future trends in online retail. The findings indicate that VR and MR technologies will continue to gain momentum, transforming the way consumers shop online. The study suggests that future retail virtual stores will offer more immersive and interactive experiences, potentially changing the landscape of online shopping (Stenlin, 2022).

Jain et al. (2021) explored the omnichannel retail customer experience with mixed-reality shopping assistant systems. Their study utilized design science research methodology to develop a system that included product information, reviews, recommendations, and a purchase option. The research involved evaluating the system with two different head-mounted displays, Microsoft HoloLens and HoloLens 2, and 29 participants. The results showed a positive customer attitude towards the technology, with significant effects on technology adoption, enjoyment, and security beliefs. The study highlighted the potential of MR to enhance customer interaction and personalization in retail, particularly in terms of perceived convenience, service quality, and overall attitude towards the retailer. These findings suggest that MR technologies will become increasingly important in creating engaging and interactive shopping experiences in the future (Jain et al., 2021).

The future projections for MR in retail point towards a more immersive, interactive, and comprehensive shopping experience. The integration of MR technologies is expected to redefine the retail sector, influencing consumer behavior, enhancing the shopping experience, and offering innovative solutions that cater to the digital natives of today. As MR technologies continue to evolve, they are poised to play a pivotal role in shaping the future of retail, offering new opportunities for retailers to engage with their customers in more meaningful ways.

4.2. Economic Implications of Mixed Reality in Retail

The integration of Mixed Reality (MR) in retail has significant economic implications, affecting market dynamics, consumer behavior, and financial strategies. Chernyak & Yakymchuk (2021) conducted a study to assess the impact of COVID-19 on grocery retail in Ukraine, providing insights into the broader economic implications of digital transformation in retail. The research employed Machine Learning methods to analyze the effects of government-imposed restrictions and their impact on consumer behavior and retail business models. The study found that the pandemic accelerated the transition from traditional sales channels to online shopping, leading to a sharp growth in convenience and hard-discount store sectors. This shift in consumer behavior towards digital channels, including those enabled by MR technologies, suggests significant economic implications for the retail sector. The research highlights the need for retail businesses to adapt to changing market conditions and consumer preferences, particularly in the context of digital transformation (Chernyak & Yakymchuk, 2021).

Khurram et al. (2019) explored market efficiency, financial integration, and shock transmission in D-8 economies, providing insights into the economic dynamics relevant to the retail sector. The study used various econometric tests to analyze market data and assess the efficiency of equity markets. The findings indicated that technological advancements, including those in MR, could lead to market inefficiencies and opportunities for arbitrage. The research suggested that economic integration and cooperation among economies could enhance growth opportunities in trade and corporate investments, including in the retail sector. This study highlights the economic implications of technological advancements and market dynamics for retail businesses (Khurram et al., 2019).

The economic implications of MR in retail are multifaceted, encompassing market dynamics, consumer behavior, and financial strategies. The integration of MR and other digital technologies in retail is not only transforming the shopping experience but also reshaping the economic landscape of the sector. Retail businesses must adapt to these changes, leveraging technological advancements to enhance market efficiency, consumer engagement, and sustainability.

4.2.1. Cost-Benefit Analysis for Retailers

The adoption of Mixed Reality (MR) in retail presents both costs and benefits that need to be carefully analyzed for effective implementation. Jain et al. (2023) presented the design of a mixed-reality shopping assistant system in omnichannel retail, offering insights into the cost-benefit aspects of such systems. The research utilized Microsoft HoloLens 2 to develop a personal shopping assistance system that incorporated various elements like product information, reviews, and recommendations. The study conducted a qualitative analysis with 35 participants to gather feedback on the system. The findings revealed that while the implementation of such MR systems involves significant costs, including technology development and user interface design, the benefits in terms of enhanced consumer information search and decision-making are substantial. The research proposed design principles to support future developments of MR shopping applications, emphasizing the need for balancing costs with the potential benefits in enhancing the retail experience (Jain et al., 2023).

Sounderpandian et al. (2006) focused on the cost-benefit analysis of RFID implementations in retail stores, which is closely related to MR technologies. The study considered the supply chain comprising the manufacturer, distributor, retailer, and consumer, and analyzed the costs and benefits of RFID tag implementations. The models proposed in the research considered the cost of implementations, including tag readers, communication network cost, and other infrastructure costs. The benefits analyzed included automatic checkout at retail stores and reduced inventory costs due to efficient shelf replenishment. This study provides a framework for retailers to analyze the cost-benefit aspects of adopting MR and related technologies, highlighting the importance of efficient implementation to maximize benefits (Sounderpandian et al. 2006).

Cheng et al. (2019) explored the application of MR in the Hong Kong jewellery industry, specifically for virtual jewellery fitting. The study developed a mixed reality for virtual jewellery fitting (MRVJF) system aimed at tackling challenges in e-commerce, such as product visualization and personalized marketing. The research assessed the cost of developing the MRVJF system against its potential benefits, including improved jewellery visualization and user-friendliness. The findings suggest that while the initial development costs of such MR systems can be significant, the potential benefits in terms of increased competitiveness and customer engagement in the retail sector are considerable. This study underscores the economic implications of MR in retail, particularly in enhancing product visualization and marketing strategies (Cheng et al. 2019).

The cost-benefit analysis for retailers in mixed reality retail involves evaluating the significant investment costs against the potential benefits of enhanced consumer experiences and operational efficiencies. Retailers need to consider various factors, including technology development, user interface design, and integration into existing systems, to effectively leverage MR technologies. The potential benefits, such as improved customer engagement, decision-making, and marketing strategies, can significantly outweigh the costs, making MR a valuable investment for the future of retail.

5. Conclusions

The study highlights that Mixed Reality (MR) significantly enhances the shopping experience by creating immersive environments. These environments lead to deeper customer engagement through interactive and personalized experiences. MR technologies have been shown to transform traditional retail models, offering customers a blend of digital and physical retail elements. This integration not only enriches the shopping experience but also fosters a deeper connection between consumers and brands.

MR in retail presents substantial economic implications, including market growth and new financial opportunities. The adoption of MR technologies is reshaping the retail landscape, influencing consumer behavior, and enhancing operational efficiency. However, the economic impact of MR extends beyond just sales enhancement; it includes the potential for cost savings, improved customer insights, and the creation of new business models. Retailers adopting MR can expect a competitive edge in the market, provided they navigate the associated costs and integration challenges effectively.

For retail stakeholders, it is recommended to invest in MR technologies strategically, considering both the customer experience and operational efficiency. Retailers should focus on training staff, integrating MR with existing systems, and continuously evaluating the technology's impact on business performance. For policymakers, the study suggests the development of regulatory frameworks and standards specific to MR in retail. These should address data privacy, consumer protection, and ethical use of technology, ensuring a safe and equitable retail environment.

Future research should focus on longitudinal studies to assess the long-term impact of MR in retail. There is a need for empirical research examining the return on investment of MR technologies in different retail settings. Additionally, research should explore the scalability of MR solutions for small and medium-sized enterprises. Investigating the socio-cultural impact of MR in retail, particularly in terms of consumer behavior and retail workforce dynamics, will also be crucial. Finally, as MR technology continues to evolve, ongoing research will be essential to keep pace with its advancements and implications in the retail sector.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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