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Transforming Online Retail: The Impact of Augmented and Virtual Reality on Consumer Engagement and Experience in E-Commerce[1]

Çevrimiçi Perakendeciliği Dönüştürmek: Artırılmış ve Sanal Gerçekliğin E-Ticarette Tüketici Katılımı ve Deneyimi Üzerindeki Etkisi

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ABSTRACT

This study investigates the transformative role of augmented reality (AR) and virtual reality (VR) technologies in e-commerce and digital marketing. A systematic literature review synthesizes findings from empirical and theoretical studies published between 2011 and 2024. The findings indicate that AR enhances online shopping through features such as virtual try-ons and spatial placement visualization, reducing return rates and increasing purchase confidence. VR, on the other hand, provides immersive environments that simulate physical shopping experiences, strengthening consumer-brand connections. Both technologies exhibit immediate costs but offer long-term benefits, positively influencing conversion rates and customer loyalty. This study contributes to consumer behavior research by applying value perception models, immersive technology frameworks, and engagement metrics to the e-commerce landscape. The research underscores the strategic importance of integrating AR and VR into digital marketing and e-commerce platforms. While this study synthesizes existing literature, empirical validation through longitudinal studies and cross-industry applications is necessary

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ÖZ

Bu çalışma, artırılmış gerçeklik (AR) ve sanal gerçeklik (VR) teknolojilerinin e-ticaret ve dijital pazarlamada dönüştürücü rolünü incelemektedir. 2011 ve 2024 yılları arasında yayımlanan ampirik ve teorik çalışmalardan elde edilen bulguların sistematik bir literatür incelemesi yapılmıştır. Bulgular, AR'nin sanal deneme ve mekansal yerleşim görselleştirmesi gibi özelliklerle çevrimiçi alışverişi geliştirdiğini, iade oranlarını düşürdüğünü ve satın alma güvenini artırdığını göstermektedir. Öte yandan, VR fiziksel alışveriş deneyimlerini simüle eden sürükleyici ortamlar sunarak tüketici-marka bağlarını güçlendirmektedir. Her iki teknoloji de kısa vadede maliyetler getirse de uzun vadede dönüşüm oranları ve müşteri sadakati üzerinde olumlu etkiler sağlayan faydalar sunmaktadır. Bu çalışma, değer algısı modelleri, sürükleyici teknoloji çerçeveleri ve etkileşim ölçütlerini e-ticaret alanına uygulayarak tüketici davranışları araştırmasına katkıda bulunmaktadır. Araştırma, AR ve VR'nin dijital pazarlama ve e-ticaret platformlarına entegrasyonunun stratejik önemini vurgulamaktadır. Bu çalışma mevcut literatürü sentezlese de, uzun vadeli çalışmalar ve sektörler arası uygulamalarla ampirik doğrulamanın gerekli olduğu belirtilmektedir.

[1] This study was previously published as an abstract at III. International Congress of Social, Political and Financial Researches (USSMAK).

Introduction

These global players shape the market by driving innovation, expanding product offerings, and tapping into new consumer demographics. The industry's rapid growth is further fueled by trends such as sustainability, ethical production practices, and the increasing demand for personalized beauty products. With a growing emphasis on digital marketing, social media influence, and influencer collaborations, the cosmetic industry thrives in a highly competitive and dynamic global market. The rapid technological advancements over recent decades have dramatically transformed everyday life, particularly in retail. E-commerce has surged as a dominant force, shifting consumer shopping behavior from brick-and-mortar stores to online platforms. As of recent reports, 43% of shopping activities are now conducted exclusively online, reflecting the ongoing growth of e-commerce, valued at €2.3 trillion globally in 2017 and projected to double by 2022. However, despite the convenience and growth of online shopping, it often lacks the emotional engagement and immersive experiences that physical stores offer. Augmented Reality (AR) and Virtual Reality (VR) have emerged as potential solutions for more prosperous, interactive online shopping experiences. These technologies enable consumers to engage with products more personally and dynamically, which could help bridge the gap between expectations and actual product experiences, potentially reducing issues such as high return rates. This study explores the impact of 3D product visualizations in e-commerce on consumer shopping experiences, focusing on how these technologies might revolutionize online retail by enhancing sensory engagement and emotional connection. Augmented Reality (AR) is a powerful perception strategy that enhances the real world by overlaying computer-generated graphics. It has broad applications, including e-commerce, where it can significantly improve customer experiences. AR enables consumers to visualize products and interact with virtual elements in the physical environment. This technology addresses the "try before you buy" challenge, offering a more immersive shopping experience, especially in online settings where users increasingly seek realistic visual and material simulations (Muñoz et al. 2020; Calabuig-Moreno et al. 2020). E-commerce businesses incorporate rich media content to enhance online shopping, such as high-resolution images, videos, and 3D designs. AR is particularly promising in creating dynamic and engaging interfaces that provide customers with an improved, more interactive experience. Despite its potential, the adoption of AR in e-commerce remains limited, with companies still exploring how best to leverage this technology to improve consumer interaction and drive sales. Integrating Virtual Reality (VR) and Augmented Reality (AR) has revolutionized e-commerce, reshaping how consumers interact with online shopping platforms. In recent years, VR and AR have gained immense attention, especially after significant investments from companies like Mark Zuckerberg's purchase of Oculus for €2 billion. Industry giants such as Sony, Samsung, HTC, and Google are heavily investing in these technologies, which initially emerged in computer graphics but have expanded into various fields. VR creates immersive environments by engaging the senses, while AR merges digital objects with the real world, as seen in games like Pokémon Go. These innovations address key challenges in e-commerce, such as building consumer trust and enhancing product visualization (Muñoz et al. 2020; Calabuig-Moreno et al. 2020; Al-Ansi et al. 2023; Creed et al. 2024).

By 2030, VR and AR are expected to contribute an additional €1.5 trillion to the global economy, with brands using these technologies to engage and inspire consumers in unprecedented ways, like Samsung's virtual moonwalk or Oreo immersive experience of its new product. Advances in technologies like augmented Reality (AR), virtual reality (VR), the Internet of Things (IoT), and artificial intelligence (AI) are revolutionizing marketing. AR, in particular, is gaining significant traction in digital marketing. This technology overlays digital content—images, videos, text, and audio—onto real-world environments using smartphones and tablets. With the rise of mobile AR apps, businesses are leveraging AR to offer unique, interactive experiences that engage customers, influence purchasing decisions, and enhance brand loyalty. AR's use in retail allows consumers to try products virtually before buying, improving their shopping experience and increasing sales. Brands like Ray-Ban and Sephora are already incorporating AR into their strategies. As customer engagement becomes increasingly important, AR provides a powerful tool for fostering deeper emotional connections and promoting brand awareness. The technology's potential to drive customer brand engagement (CBE) highlights its value in shaping modern marketing approaches. This study will explore how AR influences CBE and the factors that make AR an effective marketing tool. Virtual Reality (VR) is revolutionizing various industries by creating immersive experiences through pose tracking and 3D displays. Beyond gaming, VR is transforming business, education, and entertainment sectors, offering applications such as training simulations and enhanced customer interactions. With the rise of extended Reality (XR), which includes augmented and mixed reality, the lines between the digital and physical worlds are becoming increasingly blurred. In e-commerce, VR is helping businesses replicate real-world shopping experiences, bridging the gap between online and in-store retail. This paper explores how VR impacts consumer behavior, retail experiences, and the broader shopping journey, highlighting its potential to enhance customer engagement and transform business strategies. Through qualitative research, including interviews with industry professionals and users, the study reveals that while VR offers exciting opportunities, companies must adopt a well-planned strategy to leverage its potential fully. Augmented Reality (AR) is a technology that overlays

digital content onto the physical world, creating an interface between the two realms (Javornik, 2016b; Porter & Heppelmann, 2017; Yim, Chu, & Sauer, 2017). In retail, AR enhances the shopping experience by allowing customers to visualize how products will look in their environment or on themselves, eliminating the need for imagination (Heller et al., 2019a; Hilken et al., 2017; Verhagen et al., 2014). This technology not only reduces travel and shopping time but also aids in translating two-dimensional information into a three-dimensional context, which aligns with consumers' natural information-processing abilities (Hilken et al., 2017; Porter & Heppelmann, 2017). Ultimately, AR can improve decision-making, accelerate information assimilation, and elevate the shopping experience (Dacko, 2017; Huang & Liao, 2015). Augmented Reality (AR) is increasingly integrated into digital marketing strategies by retailers, alongside Virtual Reality (VR) as part of Extended Reality (XR) technology. AR enhances the customer experience by blending virtual elements, like 3D models or text, with the real world. This interaction allows customers to control product features (size, rotation, position), making it easier to visualize items in real-life settings, such as furniture in their homes. AR is accessible via smartphones and tablets, making it a convenient tool for retailers like IKEA, Sephora, and Starbucks to support pre-purchase decision-making. The use of AR is skyrocketing, with over 1 billion users expected by 2024. This growth parallels the rise in smartphone usage, offering brands a valuable opportunity to boost sales through AR apps.

Research has shown that AR apps positively influence consumer behavior, such as increased purchase intent, loyalty, and social sharing. Word-of-mouth (WOM) plays a crucial role, as customers will likely share their positive AR experiences, amplifying the product's reach. However, there is limited research on the psychological effects of AR features on consumer behavior, particularly regarding WOM intention. This study aims to explore how AR features influence customer emotions (pleasure and arousal) and whether these emotions mediate the relationship between AR app features and WOM intention, offering insights for marketers.[8] Augmented Reality (AR) and Virtual Reality (VR) are transforming the e-commerce landscape by delivering innovative solutions to long-standing challenges in online retail. These technologies provide immersive, interactive, and personalized shopping experiences, reshaping how consumers interact with products and making online shopping more engaging. AR allows users to virtually try products and visualize them in real life, while VR immerses them in simulated environments, offering a deeper exploration of products. They bridge the gap between traditional shopping and e-commerce, enhancing customer satisfaction and reducing uncertainties. This literature review explores the profound impact of AR and VR on consumer behavior, e-commerce businesses, and the industry's competitive dynamics.[9] In 2020, E-commerce saw a significant boost, with companies like Walmart and Amazon driving a 42% increase in online sales, totaling €4.06 trillion. Cart abandonment remains a challenge despite this growth, with 77.3% of shoppers leaving without completing purchases. Augmented Reality (AR) offers a solution by allowing consumers to try products, improving decision-making, and boosting confidence virtually. As the AR market expands, E-commerce businesses adopting this technology can expect higher conversion rates and a competitive edge. E-commerce has transformed business practices, enabling global reach, cost reduction, and higher returns. With the rise of the Internet, businesses are using new technologies like Augmented Reality (AR) to enhance customer experiences. AR blends the physical world with digital content, offering immersive, interactive experiences. This technology improves product visualization, marketing, and customer engagement. By leveraging AR, businesses can create innovative ways for consumers to explore products, revolutionizing the shopping experience and unlocking new opportunities in the digital age (Al-Ansi et al. 2023; Creed et al. 2024).

1. An Overview

To achieve a more substantial emotionally engaging experience in e-commerce and thus a higher consumer engagement, 3D product visualizations via AR and VR have received increasing attention from retailers in recent years (Sihi, 2018). However, caution is required as an inadequate integration of a visualization type may negatively influence consumers' brand perception and brand success in the long run (Y. Liu et al., 2020; Su et al., 2020). Therefore, this chapter focuses on the theoretical contributions and practical implementations of AR and VR 3D product visualizations in e-commerce compared to the widespread 2D product images (Muñoz et al. 2020; Calabuig-Moreno et al. 2020; Al-Ansi et al. 2023; Creed et al. 2024).

1.1. E-commerce

The first electronic retail transaction on August 11, 1994, introduced the term e-commerce and revolutionized shopping habits (Jaller & Pahwa, 2020). E-commerce allows businesses to offer personalized experiences by understanding customer preferences, providing the right products at the right time, and expanding their reach globally (Elboudali et al., 2020; Paz & Delgado, 2020). This flexibility and convenience are key drivers for e-commerce's rapid growth, with positive feedback and continued expansion forecasted (Klaus, 2020; Jaller & Pahwa, 2020). Despite its success, e-commerce still faces challenges in replicating the sensory experiences of

physical stores, particularly regarding product visualization (Paz & Delgado, 2020). Most online retailers use static 2D images, limiting the sensory engagement consumers experience in brick-and-mortar stores (Elboudali et al., 2020; K. H. Liu et al., 2020). 3D visualizations could enhance this experience by providing more detailed and interactive product information (Jessen et al., 2020; Y. Liu et al., 2020), allowing consumers to engage more deeply with the products they are considering (Haile & Kang, 2020). However, while 3D technology solves this gap, it must be implemented carefully to avoid overwhelming users (Do et al., 2020; Sihi, 2018). The success of these innovations depends on creating an engaging yet manageable shopping experience (Jang et al., 2019). Given the growing expectations for e-commerce to surpass brick-and-mortar experiences, the challenge lies in effectively integrating these features (Xue et al., 2020; Klaus, 2020).

1.2. 3D Product Visualizations

Technological developments like AR and VR have recently become a focus for retailers in e-commerce despite being used in other business areas for years (Rauschnabel, 2018; Romano et al., 2020; Sung, 2021; Xue et al., 2020). Four key factors drive this shift: 1) AR and VR help retailers differentiate from competitors (Sihi, 2018), 2) differentiation attracts more consumers in a competitive market (Sihi, 2018), 3) these technologies provide richer product information, reducing purchase risks and returns (Jessen et al., 2020; Lee & Xu, 2018; Liu et al., 2020; Sihi, 2018; Veneruso et al., 2020), and 4) they enhance the overall online shopping experience (Sihi, 2018).

1.3. Augmented Reality

As Y. Liu et al. (2020) stated, Augmented Reality (AR) overlays computer-generated 3D objects onto a real-world environment. Dacko (2017) builds on Azuma's (1997) theory, emphasizing three key pillars of AR: 1) combining virtual and real objects, 2) real-time interaction, and 3) perceiving virtual objects in an authentic setting. AR is also called "mixed reality" due to the coexistence of virtual and real elements (Dacko, 2017; Do et al., 2020). In retail, AR enhances the shopping experience by providing 3D product visualizations via stationary devices, enriching consumer engagement (Dacko, 2017; Park & Kim, 2021). In e-commerce, AR utilizes camera-equipped mobile devices and retailer apps for realistic 3D product displays (Haile & Kang, 2020; Y. Liu et al., 2020). Though AR has existed since the 1960s, it became more widespread in the early 2000s, offering retailers an opportunity for market differentiation (Do et al., 2020; Jessen et al., 2020). AR applications include environment augmentation.

Augmented Reality (AR) in e-commerce enables customers to virtually try products (like furniture or clothing) in their real-world environment or on their bodies. This "virtual try-on" or "magic mirror" technology reduces e-commerce's primary drawback—uncertainty—by providing a more realistic shopping experience. AR helps visualize product fit and appearance, offering utilitarian and hedonic benefits and encouraging consumer engagement. However, AR can be intrusive if overly interactive, leading to cognitive overload. Challenges include privacy concerns, especially regarding camera access, and the quality of virtual try-ons, particularly for clothing. Despite these issues, AR enhances the shopping experience by allowing consumers to interact with products in real time. However, there is a risk that it may be used more for entertainment than for transactions (Cunha et al. 2024).

1.4. Virtual Reality

Unlike AR, VR, developed in 1980, immerses users in a synthetic virtual world, allowing real-time interaction with computer-generated 3D objects and others via avatars (Cowan & Ketron, 2019; Haile & Kang, 2020). In e-commerce, VR creates a simulated shopping experience that resembles brick-and-mortar stores (Y. Liu et al., 2020). Two main VR applications in online retail are virtual fitting rooms (VFR), where consumers try on garments using avatars (Fiore et al., 2005), and recreations of physical stores where users interact with the environment and products (Meißner et al., 2020).

The shopping environment can be designed in 3D, with products viewed in detail via 360° visualization (Hewawalpita & Perera, 2017). This is particularly effective for customizable products like automobiles or fashion, allowing product attributes to be conveyed (Cowan & Ketron, 2019). This approach dominates e-commerce by offering a familiar shopping experience that mirrors offline retail (Tran et al., 2011c). However, VR simulations of brick-and-mortar stores are not yet advanced enough for whole-product interaction or transactions (Park & Kim, 2021; Tran et al., 2011a). VR enables product personalization, portfolio visualization, and the customization of online shopping environments (Elboudali et al., 2020; Papagiannidis et al., 2013). It provides a "first-hand experience," reducing purchase risk by allowing a closer inspection of details like material and design (Cowan & Ketron, 2019; Fiore et al., 2005; Sihi, 2018; Su et al., 2020; Tran et al., 2011a). However, VR integration in e-commerce has drawbacks. Interactivity is often limited (Jang et al., 2019), and the low integration rate of VR leads to poor body representations and a lack of gestures or facial expressions, which negatively affects

the shopping experience (Y. Liu et al., 2020). While VR simulations convey some product details, the absence of a payment system reduces the immediate appeal for new users (Jang et al., 2019; Tran et al., 2011c). Simply simulating brick-and-mortar stores is insufficient; the virtual shopping experience should be as realistic as possible (Papagiannidis et al., 2013; Tran et al., 2011c). The realistic visualization of products should not be neglected, and it is important to allow detailed examination and interaction through high-quality rendered content (Meißner et al., 2020; Wodehouse & Abba, 2016).

2. Integration of Augmented Reality (AR) and Virtual Reality (VR) in E-commerce

Augmented Reality (AR) and Virtual Reality (VR) technologies are increasingly recognized as transformative tools in marketing and e-commerce, offering innovative ways to enhance consumer experiences and meet the growing demands of modern shoppers. This review synthesizes insights from recent research, emphasizing the applications, challenges, and future directions of AR and VR in retail and digital marketing (Vivek & Krupskyi, 2024).

2.1. The Role of AR in Marketing and Consumer Experience

According to Cruz (2021), AR has transitioned from a novel technological feature to a strategic imperative for businesses striving to differentiate themselves in competitive markets. Its application in 3D product visualizations has demonstrated the potential to deliver immersive and interactive consumer experiences. A comparative study of AR, VR, and 2D imagery revealed that while 2D images remain the most engaging overall, AR outperforms VR, particularly for older demographic groups. Despite these advantages, research indicates that neither AR nor VR is inherently superior for specific product types. This suggests that AR serves as a complementary tool to traditional imagery, enhancing engagement and offering unique shopping experiences.

2.2. AR as a Catalyst for E-commerce Growth

Befort (2021) highlights AR's impact on revolutionizing e-commerce by enabling customers to visualize products in real-world contexts. Features such as overlaying 3D models in physical environments improve purchase decision-making, with 77% of surveyed customers reporting a preference for AR-enhanced product visualizations. Similarly, Garg and Pareek (2021) document the exponential growth of the AR market, from €640.4 million in 2015 to projected revenues of €120 billion by 2020. Companies like IKEA and Converse leverage AR to allow users to preview furniture and footwear within their homes, increasing customer satisfaction, engagement, and sales.

2.3.Virtual Reality in E-commerce

VR technologies, while less prevalent than AR in retail, offer immersive online shopping experiences through tools like VR headsets and gloves. Suman Vineet (2021) explores VR's ability to blend 2D web elements with 3D interactions, enhancing user trust and engagement. A/B testing has been employed to optimize these experiences, focusing on interface design and consumer interaction. Advanced tools like photogrammetry and AI-driven customization further deepen emotional connections with customers, despite VR's higher costs and technical barriers compared to AR (Cunha et al. 2024).

2.4. Challenges and Limitations

The adoption of AR and VR faces significant hurdles. Ronaldo and Wahab (2022) emphasize that while AR offers vivid and interactive experiences, its effectiveness varies based on product types and user demographics. For instance, AR applications for wearable products like watches may require precise user positioning, potentially detracting from the experience. Mohan Palani (2023) underscores a lack of comprehensive data on AR's practical applications in retail, highlighting the need for systematic studies that bridge theoretical and real-world insights.

2.5. Gamification in E-commerce

The integration of gamification into e-commerce platforms is a growing trend, as detailed by Jia and Yu (2024). Gamification employs game design elements such as rewards and challenges to enhance consumer engagement and influence behaviors like purchase intention and brand loyalty. This is supported by Rauh, Straubert, and Sucky (2024), whose research demonstrates that gamification can encourage sustainable shopping practices and long-term user engagement. Behavioral models, including affordance theory and the S-O-R framework, illustrate the psychological mechanisms driving these outcomes (Muñoz et al. 2020; Calabuig-Moreno et al. 2020; Al-Ansi et al. 2023; Creed et al. 2024).

2.6. Consumer Behavior and Engagement

Ebrahimi et al. (2024) define brand engagement as a psychological state fostered by positive, interactive experiences with a brand. AR and VR technologies enhance this engagement by providing personalized, immersive shopping journeys. However, as Semenda et al. (2024) note, digital marketing strategies must adapt to consumer-driven platforms like social media, where user-generated content plays a pivotal role in shaping brand perception.

2.7. Technological Innovations and Applications

AR and VR technologies are increasingly integrated with AI to deliver tailored shopping experiences. For instance, Al Khaldy et al. (2023) describes how AR-powered virtual try-on applications for beauty products utilize facial tracking and machine learning to analyze skin texture and tone, providing personalized recommendations. These advancements demonstrate the potential for AR and VR to drive innovation and efficiency in e-commerce (Cunha et al. 2024).

2.8. Market Trends and Future Directions

Bakirlioglu et al. (2022) highlight the critical role of digital marketing, supply chain management, and electronic payment systems in supporting AR and VR adoption. Despite challenges such as high implementation costs and limited accessibility, predictive models suggest sustained growth in these technologies. Systematic reviews and bibliometric analyses, as conducted by Peštek and Osmanović (2022), reveal a positive correlation between AR adoption and improved customer loyalty, sales, and communication strategies.

The integration of AR and VR in e-commerce presents significant opportunities for enhancing customer engagement, satisfaction, and loyalty. However, limitations such as high costs, accessibility barriers, and fragmented research data must be addressed. Future studies should focus on cross-industry applications, age-related differences, and long-term consumer behavior to unlock the full potential of these technologies. As AR and VR continue to evolve, their ability to transform digital marketing and e-commerce landscapes will depend on strategic investments in innovation, user experience design, and data-driven insights (Vivek & Krupskyi, 2024).

3. Design and Hypotheses

Retailers should recognize that virtual shopping environments in e-commerce enhance existing retail channels by making them more engaging rather than replacing them (Jang et al., 2019; Tran et al., 2011a). When incorporating 3D visualizations, it is crucial to ensure that the visualization type is appropriate for the product (Nikhashemi et al., 2021). Retailers must also consider their products' features, functions, and customization options (Altarteer et al., 2013). Based on these considerations, the following hypotheses are proposed

H1: AR and VR 3D product visualization enhances consumers' e-commerce experience compared to 2D product images.

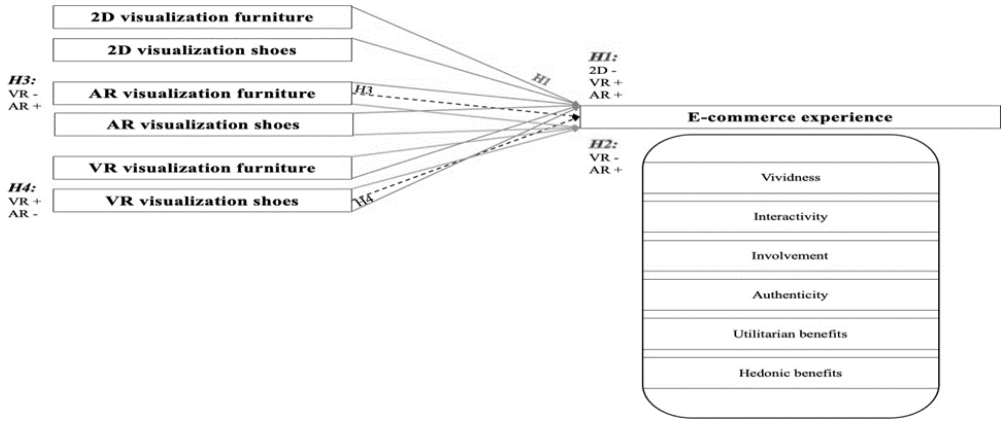
H2: AR 3D product visualization enhances consumers' e-commerce experience compared to VR 3D product visualizations.

H3: An AR 3D product visualization is more suitable for a product whose spatial placement is crucial than for a product where attention to detail is important

H4: A VR 3D product visualization is more suitable for a product where attention to detail is important than a product whose spatial placement is crucial

An experiment with a between-respondent design assessed how different visualization types influence the e-commerce experience for various product types. AR was tested with furniture, which benefits from spatial visualization, while VR was used for shoes requiring detailed customization. The hypothesized relationships between these variables are illustrated in the conceptual model in Figure 1.

Figure 1: Conceptual Model

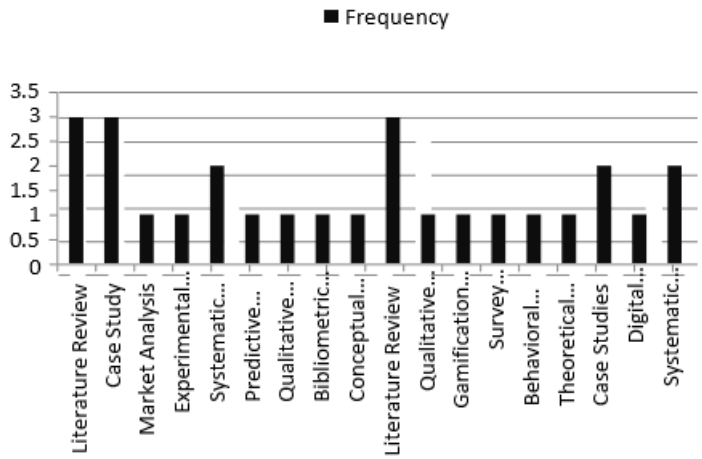


4. Extracted Statistics

The list of research methods provided includes a variety of approaches commonly used in academic and professional studies. Literature Reviews and Systematic Reviews are both prominent in the field of research, each appearing twice, as they play a crucial role in synthesizing existing knowledge and identifying gaps or trends. Case studies are also featured twice, emphasizing the importance of in-depth, context-specific research in real-world phenomena. Other methods such as Market Analysis, Experimental Studies, Predictive Modeling, and Qualitative

Research appear once, each contributing a distinct approach to gathering data and analyzing trends within specific fields. Additionally, bibliometric Analysis, conceptual framework, and qualitative Analysis are often used to understand theoretical concepts or analyze non-numerical data. Gamification Analysis, Survey Experiments, and Behavioral Analysis highlight the growing interest in understanding human behavior, motivation, and decision-making. Theoretical Exploration offers insights into the development or testing of theories, while Digital Marketing Analysis focuses on assessing the effectiveness of digital marketing9 strategies. These methods collectively represent a diverse toolkit for addressing various research questions across disciplines.

Figure 2: Statistical Representation of the Method (Frequency)

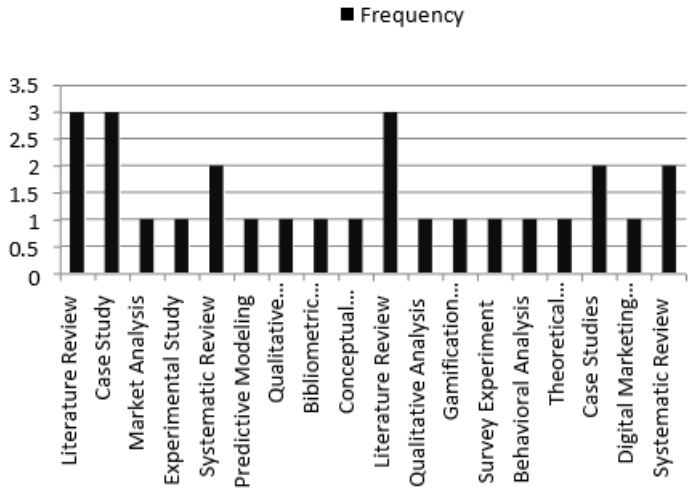


The Dataset includes a wide range of categories, each with varying frequencies. For example, "Customer data from e-commerce platforms" appears five times, while "User interaction data" is encountered seven times. Some categories, such as "Peer-reviewed articles" and "Web of Science and Scopus," are highly represented with 10

and 8 occurrences, respectively. Meanwhile, data related to augmented reality (AR) applications, including "AR market growth data" and "Digital marketing and AR interactions," appear three times each. Other areas, such as "College student samples" and "Gamification elements in e-commerce," show a frequency of four.

Additionally, user experience data, customer engagement metrics, and social media behavior are each recorded multiple times, reflecting their importance in e-commerce research. Categories like "Survey of 973 U.S. online shoppers" and "Citation and co-citation data" appear less frequently, indicating their more specialized use. Overall, the Dataset provides a comprehensive view of various aspects of e-commerce, marketing, and AR interactions, with specific areas being more prevalent in the research.

Figure 3: Statistical representation of the Dataset (Frequency)



The research findings reveal several key insights into the impact of augmented Reality (AR), Virtual Reality (VR), and gamification on consumer behavior and e-commerce. Notably, AR is frequently highlighted for enhancing consumer experiences, improving purchase decisions, boosting engagement and sales, and driving adoption, with multiple studies noting its ability to improve marketing communication and customer interaction. Similarly, AR's role in e-commerce growth and its ability to engage younger audiences are frequently cited, demonstrating its strong influence in these areas. On the other hand, VR is often recognized for enhancing trust and user experience, albeit with slightly less frequency. Gamification is also a prominent theme, with multiple studies showing its influence on consumer behavior, its ability to promote sustainable shopping and its effectiveness in boosting engagement and word-of-mouth. Gamification is also linked to enhanced user motivation and brand engagement, contributing to increased customer loyalty. Finally, some research emphasizes the broader role of AR/VR and gamification, such as in proposing conceptual frameworks for AR research or identifying AR's role across diverse sectors, though these findings appear less often. Together, these results underscore the growing importance of AR, VR, and gamification in shaping consumer experiences and driving engagement in the digital and e-commerce landscape.

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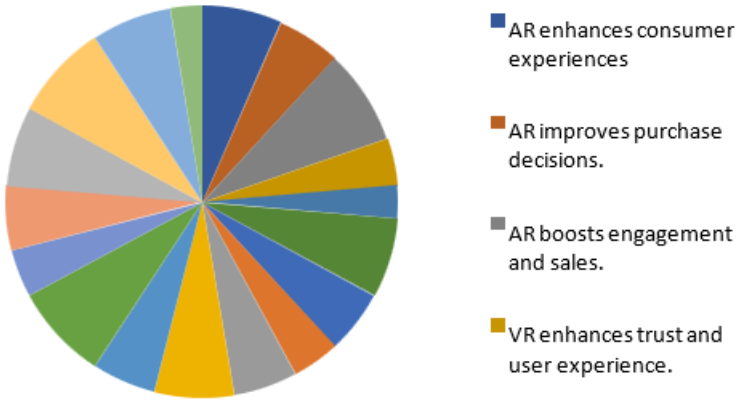
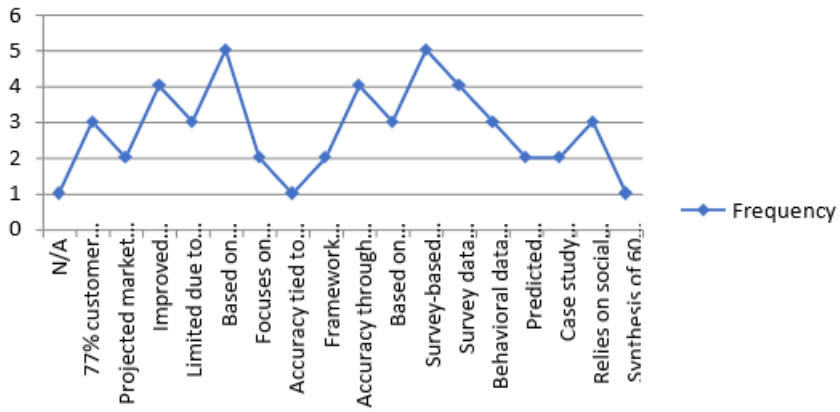
Figure 4: Statistical Representation of the Result (Frequency)



The Dataset reveals various methods used to assess accuracy in research, with specific approaches being more prominent. For instance, "Based on statistical models" and "Survey-based insights" appear frequently, indicating a firm reliance on quantitative data to validate findings. Similarly, "Survey data supports findings" and "Accuracy through comprehensive reviews" are also standard, suggesting that data derived from surveys and in-depth reviews play a crucial role in establishing accuracy. On the other hand, results like "N/A," "Accuracy tied to bibliometric methods," and "Synthesis of 60 articles" are less frequent, representing more specific or niche methods of evaluation. Additionally, concepts such as "77% customer preference for AR" and "Improved consumer trust metrics" appear several times, emphasizing the importance of consumer-related metrics in determining accuracy. Overall, the findings highlight a balanced mix of statistical, survey-based, and review-driven approaches to measuring accuracy, with some methods being more widespread than others.

Figure 5: Statistical Representation of the Accuracy (Frequency)



5. Recommendations

- Acknowledge the rapid growth of AR in e-commerce, especially its transformation from a novel technology to a critical tool in marketing and customer engagement. Highlight studies that provide quantitative evidence of AR's market expansion from €640.4 million in 2015 to projected figures like €120 billion by 2020, reflecting AR's growing importance in e-commerce.
- Discuss the role of AR in enhancing consumer engagement and providing immersive shopping experiences. Several studies suggest that AR helps consumers visualize products in real-world settings, influencing their purchase decisions and increasing satisfaction. Investigate how AR influences older generations versus younger audiences.
- Traditional 2D images. While studies indicate that 2D images remain the most engaging overall, AR offers a superior experience to VR, particularly for older consumers. This highlights the need to consider target demographics when integrating AR or VR into marketing strategies.

- Address the technological barriers and opportunities for AR adoption in e-commerce, such as the need for 3D product models, specialized teams, and high development costs. Despite these challenges, AR remains an essential strategy for differentiation and improving the customer experience in competitive e-commerce markets.
- Explore the influence of AR on consumer purchase decisions, particularly in terms of improving product visualization, reducing uncertainty, and enhancing trust. Research AR enhances consumer confidence, leading to higher conversion and reduced return rates, as it allows more informed purchasing decisions.
- Discuss how AR can improve brand engagement by offering personalized, immersive experiences that foster emotional connections with consumers. Highlight the role of AR in e-commerce platforms that integrate brand storytelling, helping brands build deeper consumer relationships.
- Investigate the varying effectiveness of AR across different age groups, as older generations may experience AR differently from younger users. This can inform businesses how to tailor AR experiences for specific demographics, ensuring greater accessibility and satisfaction.
- Propose areas for future research, such as the long-term impact of AR on brand loyalty and repeat purchases, the effectiveness of AR in different product categories, and the potential integration of AR with other technologies like Artificial Intelligence (AI) and gamification for enhanced personalization.
- Include a discussion on the role of gamification, which can be combined with AR to enhance customer engagement further and influence behaviors like purchase intention and brand loyalty. Gamification elements, such as rewards and challenges, can make AR experiences more interactive and enjoyable for consumers.

6. Discussion

Integrating advanced technologies like Augmented Reality (AR) and Virtual Reality (VR) is reshaping the e-commerce and retail industries, particularly in consumer goods sectors like cosmetics and beauty. Companies such as Procter & Gamble, Estée Lauder, and Shiseido are leveraging these technologies to innovate and engage with consumers in more personalized and immersive ways, thus meeting the growing demand for dynamic shopping experiences. AR and VR in E-Commerce. These technologies address some key challenges e-commerce faces, such as product visualization and consumer trust. AR allows consumers to interact with products virtually, such as trying makeup or testing cosmetics digitally, which has been particularly useful in industries like beauty. For instance, Sephora and Ray-Ban have used AR to enhance their digital retail platforms, allowing customers to try products virtually before purchasing. This functionality boosts customer confidence and improves decision-making by allowing users to experience the product in real-time settings. On the other hand, VR immerses customers in simulated environments where they can explore products in-depth, as seen in the virtual experiences offered by companies like Samsung and Oreo. These immersive environments can recreate the in-store shopping experience, overcoming the limitations of online shopping by providing a more tangible sense of the product's look and feel. Consumer Engagement and Personalized Experiences A demand for personalized experiences has accompanied the rapid growth of e-commerce. Consumers no longer want just a transaction—they seek engaging, interactive, and memorable shopping experiences. AR and VR technologies cater to this demand by allowing brands to offer unique and tailored experiences that resonate emotionally with consumers. These experiences, such as visualizing how a beauty product will look on the user or walking through a virtual store, foster deeper emotional connections between the consumer and the brand.

Conclusion

Integrating Augmented Reality (AR) and Virtual Reality (VR) into e-commerce and digital marketing transforms consumers' engagement with brands and products. These technologies address critical online shopping challenges, such as limited product visualization and lack of sensory engagement, by offering immersive, interactive experiences. AR enhances real-world interaction by enabling users to visualize products in their environments, while VR creates immersive simulations replicating physical stores or introducing new virtual spaces.

The research highlights AR and VR's potential to boost customer engagement, enhance decision-making, and improve trust and satisfaction. Companies like Sephora and IKEA effectively use AR for virtual try-ons and spatial product placements, while VR offers immersive shopping experiences, such as virtual tours of products. These innovations increase conversion rates and reduce return rates, enhancing overall operational efficiency.

Despite these benefits, challenges remain, including high implementation costs, accessibility barriers, and technical limitations. As AR and VR technologies advance, strategic implementation and alignment with target demographics will be crucial. Integrating these technologies with tools like gamification and AI could further enhance personalization, engagement, and customer loyalty.

In conclusion, AR and VR are reshaping the e-commerce landscape, offering businesses opportunities to differentiate themselves and create unique, customer-centric shopping experiences. These technologies are not just trends but essential tools in driving innovation and growth in the competitive digital marketplace.

AUTHOR STATEMENT

Research and Publication Ethics Statement: This study was prepared in accordance with the rules of scientific research and publication ethics.

Ethics Committee Approval: This study does not require ethics committee approval as it does not include analyses that require ethics committee approval.

Author Contributions: Both authors contributed equally.

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