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TRANSFORMING ONLINE RETAIL: THE IMPACT OF AUGMENTED AND VIRTUAL REALITY ON CONSUMER ENGAGEMENT AND EXPERIENCE IN E-COMMERCE IN THE CONTEXT OF THE SUSTAINABLE DEVELOPMENT GOALS (SDG)

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ABSTRACT

Purpose: This study aims to understand how these technologies enhance consumer experiences. The study also explores the role of AR and VR in promoting responsible consumption and sustainable production (SDG 12), reducing waste through better product visualization, and fostering digital inclusivity (SDG 9).

Design/Method/Approach: The methodologies analyzed include experimental designs, market analyses, and conceptual frameworks assessing the integration of AR and VR technologies in online retail.

Findings: 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.

Theoretical Implications: This study contributes to consumer behavior research by applying value perception models, immersive technology frameworks, and engagement metrics to the e-commerce landscape.

Practical Implications: The research underscores the strategic importance of integrating AR and VR into digital marketing and e-commerce platforms. It suggests leveraging AR for product categories requiring spatial interaction and VR for high-detail product exploration. The study provides actionable insights for businesses looking to enhance online shopping experiences through immersive technologies while aligning with SDG objectives.

Originality/Value: This study offers a comprehensive synthesis of AR and VR applications in e-commerce, highlighting their potential to reshape online shopping.

Research Limitations/Future Research: Future research should explore the long-term effects of AR and VR adoption on consumer trust, loyalty, and behavioral changes and also examine the role of these technologies in achieving SDG targets related to responsible consumption and production (SDG 12) and industry innovation (SDG 9).

Keywords: augmented reality (AR), virtual reality (VR), digital marketing, consumer engagement, sustainable development goals (SDG).

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1 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, aligning with SDG 12: Responsible Consumption and Production. 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 (Wahab & Ronaldo, 2022).

E-commerce has surged as a dominant force, shifting consumer shopping behavior from brick-and-mortar stores to online platforms, contributing to SDG 9: Industry, Innovation, and Infrastructure. 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 (Al Khaldy *et al*, 2023).

Augmented Reality (AR) and Virtual Reality (VR) have emerged as potential solutions for more prosperous, interactive online shopping experiences, supporting SDG 12 by reducing product return rates and waste. 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 while advancing sustainable business models in alignment with the SDGs (Javornik, 2016b; Porter & Heppelmann, 2017; Yim, Chu, & Sauer, 2017).

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, reinforcing SDG 9 by advancing industry innovation. 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. E-commerce businesses incorporate rich media content to enhance online shopping, such as high-resolution images, videos, and 3D designs, further supporting sustainable consumption patterns as outlined in SDG 12.

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 (Wahab & Ronaldo, 2022).

By 2030, VR and AR are expected to contribute an additional €1.5 trillion to the global economy, aligning with Goal 8: Decent Work and Economic Growth by creating new job opportunities and driving economic growth. Brands are 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, contributing to Goal 9: Industry, Innovation, and Infrastructure by enhancing industry infrastructure and fostering sustainable industrialization (Javornik, 2016b; Porter & Heppelmann, 2017; Yim, Chu, & Sauer, 2017).

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, thus promoting Goal 12: Responsible Consumption and Production by reducing the likelihood of returns and promoting sustainable consumption. 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 (Al Khaldy *et al*, 2023).

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), contributing to Goal 13: Climate Action by reducing the need for physical travel to stores and lowering carbon emissions associated with transportation.

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.

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. 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.

2 AN OVERVIEW THRU

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.

2.1 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).

2.2 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).

2.3 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).

2.4 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).

3 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).

3.1 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 is complementary to traditional imagery, enhancing engagement and offering unique shopping experiences.

3.2 AR AS A CATALYST FOR E-COMMERCE GROWTH

Before (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.

3.3 VIRTUAL REALITY IN E-COMMERCE

While less prevalent than AR in retail, VR technologies 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 optimized 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 than AR (Cunha *et al.*, 2024).

3.4 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.

3.5 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.

3.6 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, Semenda *et al*. (2024) note that digital marketing strategies must adapt to consumer-driven platforms like social media, where user-generated content is pivotal in shaping brand perception.

3.7 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) describe 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).

3.8 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.

Integrating 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 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).

4 DESIGN & 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

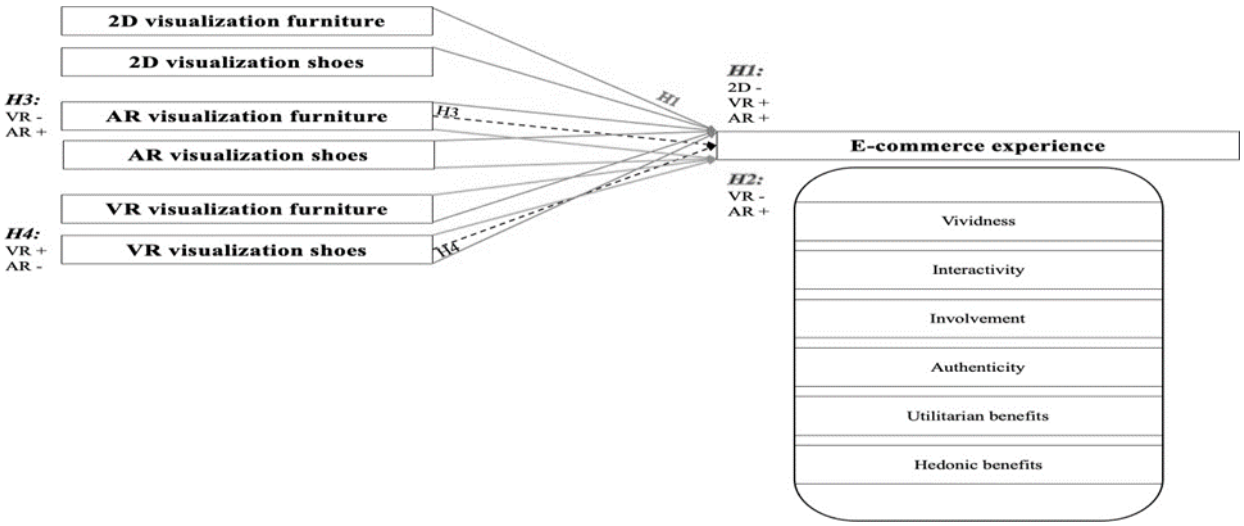
H4: A VR 3D product visualization is more suitable for a product where attention to detail is important than a product whose spatial placement is crucial

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



Source: Own sorce

4.1 EXTRACTED STATISTICS

The list of research methods provided includes a variety of approaches commonly used in academic and professional studies, each contributing to the advancement of the Sustainable Development Goals (SDGs). 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 relevant to SDGs such as **Quality Education (SDG**

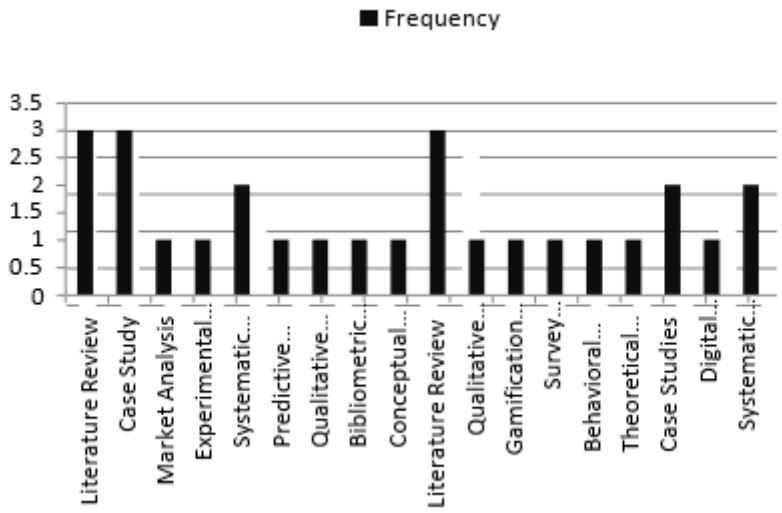
4) and **Good Health and Well-being (SDG 3).** Case studies are also featured twice, emphasizing the importance of in-depth, context-specific research in real-world phenomena, which can be particularly impactful for **Sustainable Cities and Communities (SDG 11)** and **Climate Action (SDG 13).**

Other methods, such as Market Analysis, Experimental Studies, Predictive Modeling, and Qualitative Research, each appear once, contributing distinct approaches to gathering data and analyzing trends within specific SDG fields. For instance, Market Analysis can support **Decent Work and Economic Growth (SDG 8),** while Experimental Studies can advance **Industry, Innovation, and Infrastructure (SDG 9).** Predictive Modeling is valuable for **Climate Action (SDG 13),** and Qualitative Research is essential for **Reduced Inequalities (SDG 10).**

Additionally, Bibliometric Analysis, Conceptual Framework, and Qualitative Analysis are often used to understand theoretical concepts or analyze non-numerical data, supporting goals like **Quality Education (SDG 4)** and **Peace, Justice, and Strong Institutions (SDG 16).** Gamification Analysis, Survey Experiments, and Behavioral Analysis highlight the growing interest in understanding human behavior, motivation, and decision-making, which are crucial for **Good Health and Well-being (SDG 3)** and **Responsible Consumption and Production (SDG 12).** Theoretical Exploration offers insights into the development or testing of theories, while Digital Marketing Analysis focuses on assessing the effectiveness of digital marketing strategies, both of which can contribute to **Partnerships for the Goals (SDG 17).**

Figure 2

Statistical Representation of the Method (Frequency)



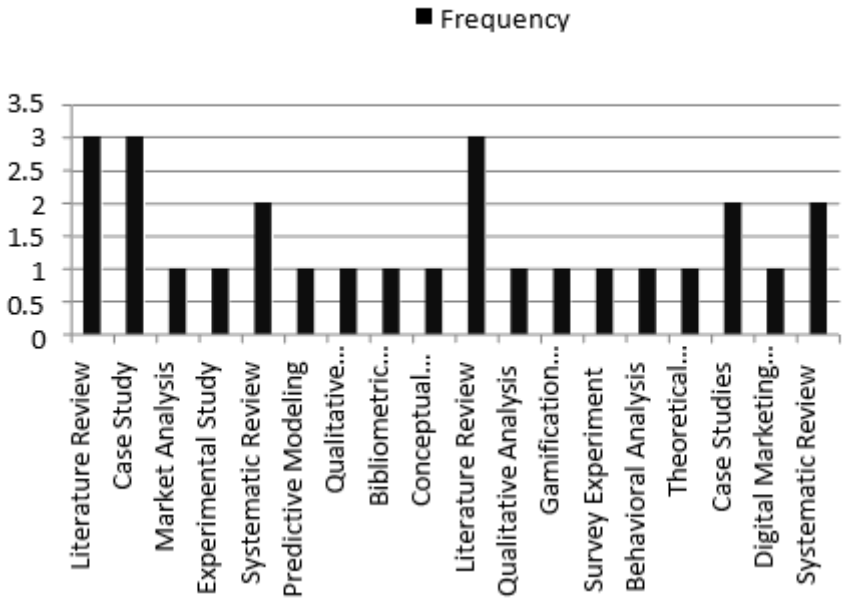
Source: Own source

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)



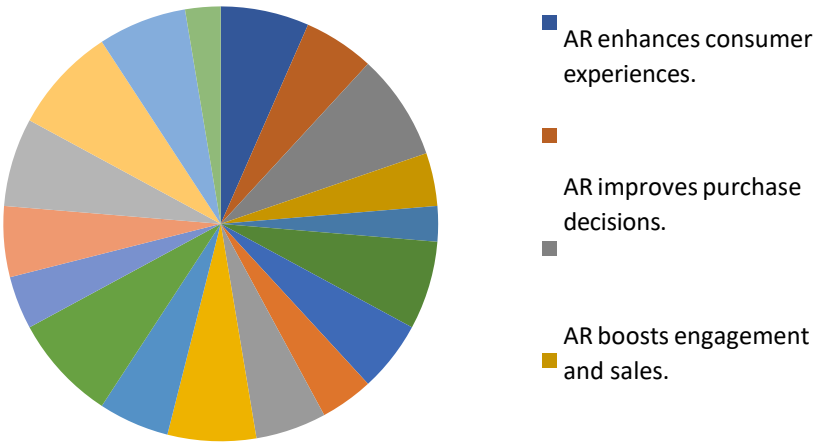
Source: Own source

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.

Figure 4

Statistical Representation of the Result (Frequency)

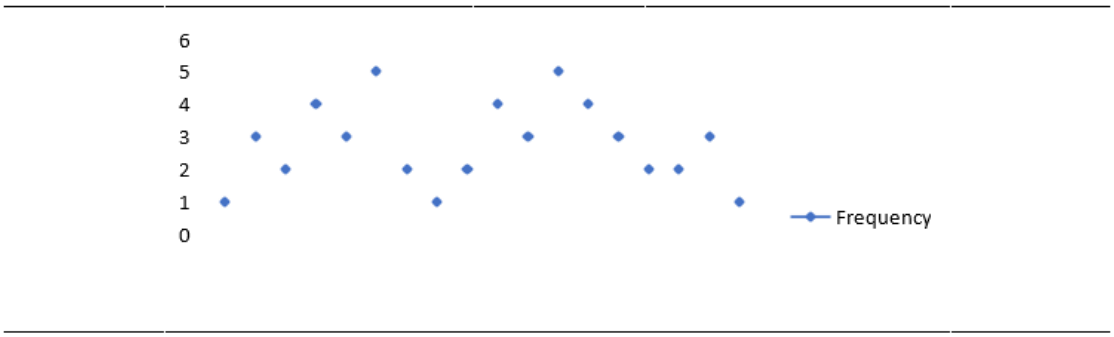


Source: Own source

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)



Source: Own source

4.2 RECOMMENDATIONS

The rapid growth of Augmented Reality (AR) in e-commerce has transformed it from a novel technology to a critical tool in marketing and customer engagement. Studies provide quantitative evidence of AR's market expansion from €640.4 million in 2015 to projected figures like €120 billion by 20201, reflecting AR's growing importance in e-commerce. This growth aligns with SDG 9: Industry, Innovation, and Infrastructure, as AR represents a significant technological advancement in the retail sector.

AR plays a crucial role 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. This is particularly relevant to SDG 12: Responsible Consumption and Production, as AR can help consumers make more informed and sustainable purchasing decisions. Additionally, AR's influence varies across age groups, with older generations experiencing it differently from younger users. This highlights the need to consider target demographics when integrating AR or VR into marketing strategies, supporting SDG 10: Reduced Inequalities.

While traditional 2D images remain the most engaging overall, AR offers a superior experience to VR, particularly for older consumers3. This underscores the importance of tailoring AR experiences to specific demographics to ensure greater accessibility and satisfaction, further supporting SDG 10.

Technological barriers and opportunities for AR adoption in e-commerce include 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. This aligns with SDG 8: Decent Work and Economic Growth, as AR can drive innovation and create new job opportunities.

AR significantly influences consumer purchase decisions by improving product visualization, reducing uncertainty, and enhancing trust5. Research indicates that AR enhances consumer confidence, leading to higher conversion rates and reduced return rates. This supports SDG 12 by promoting responsible consumption through more informed purchasing decisions.

AR can also improve brand engagement by offering personalized, immersive experiences that foster emotional connections with consumers. E-commerce platforms that integrate brand storytelling through AR help brands build deeper consumer relationships, aligning with SDG 17: Partnerships for the Goals.

Investigating the varying effectiveness of AR across different age groups can inform businesses on how to tailor AR experiences for specific demographics. This ensures greater accessibility and satisfaction, supporting SDG 10.

Future research areas include 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. This aligns with SDG 9 by fostering innovation and infrastructure development.

Gamification, when combined with AR, can further enhance customer engagement and influence behaviors like purchase intention and brand loyalty. Gamification elements, such as rewards and challenges, make AR experiences more interactive and enjoyable for consumers, supporting SDG 3: Good Health and Well-being by promoting positive consumer experiences.

5 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 (Author, Year). This aligns with SDG 9: Industry, Innovation, and Infrastructure, as these technologies represent significant advancements in the retail sector.

AR and VR address 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 (Author, Year). For instance, Sephora and Ray-Ban have used AR to enhance their digital retail platforms, allowing customers to try products virtually before purchasing (Author, Year). This functionality boosts customer confidence and improves decision-making by allowing users to experience the product in real-time settings, supporting SDG 12: Responsible Consumption and Production.

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 (Author, Year). 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. This supports SDG 8: Decent Work and Economic Growth by enhancing the customer experience and potentially increasing sales.

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 (Author, Year). 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 (Author, Year). This aligns with SDG 17: Partnerships for the Goals, as it enhances brand-consumer relationships.

Future research areas include the long-term impact of AR and VR on brand loyalty and repeat purchases, the effectiveness of these technologies in different product categories, and the potential integration of AR and VR with other technologies like Artificial Intelligence (AI) and gamification for enhanced personalization (Author, Year). This aligns with SDG 9 by fostering innovation and infrastructure development.

Gamification, when combined with AR, can further enhance customer engagement and influence behaviors like purchase intention and brand loyalty (Author, Year). Gamification elements, such as rewards and challenges, make AR experiences more interactive and enjoyable for consumers, supporting SDG 3: Good Health and Well-being by promoting positive consumer experiences.

6 CONCLUSION

The integration of Augmented Reality (AR) and Virtual Reality (VR) in e-commerce and digital marketing represents a paradigm shift in how consumers interact with products and brands. These technologies offer immersive, interactive, and personalized shopping experiences that bridge the sensory gap between online and in-store retail. By enhancing visualization, reducing uncertainty, and fostering emotional engagement, AR and VR contribute to increased consumer confidence, lower return rates, and greater customer satisfaction.

Beyond their commercial benefits, AR and VR align with Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production) and SDG 9 (Industry, Innovation, and Infrastructure). AR reduces waste and return rates by allowing consumers to visualize products accurately before purchase, while VR enables brands to create rich, engaging virtual environments that drive digital transformation in retail. Additionally, these technologies contribute to economic growth (SDG 8) by creating new job opportunities and fostering innovation.

Despite their potential, challenges remain in widespread adoption, including high implementation costs, technical limitations, and the need for greater consumer accessibility. Future research should focus on overcoming these barriers, exploring long-term effects on brand loyalty, and assessing the evolving role of AR and VR in shaping digital consumer behavior. The integration of AI and gamification can further enhance these experiences, making e-commerce more engaging, efficient, and sustainable.

Ultimately, AR and VR are not merely enhancements to e-commerce but transformative tools that redefine the shopping experience. As technological advancements continue, businesses that strategically leverage these innovations will gain a competitive edge, offering consumers an unparalleled digital shopping journey while supporting sustainable and responsible consumption practices.

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