Journal of Informatics Education and Research
ISSN: 1526-4726
Vol 5 Issue 3 (2025)

Bridging virtual and physical retail through augmented reality: A multi-method analysis of consumer behaviour

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Abstract
In today's fast-paced digital landscape, consumer expectations around online shopping are rapidly evolving. Beyond mere convenience, customers now seek engaging, personalized, and immersive experiences. Augmented Reality (AR) is emerging as a transformative technology that redefines online shopping by enabling users to visualize products in real-time, thereby enhancing decision-making and fostering deeper brand trust. This study explores the impact of AR-driven features such as virtual try-ons, 3D product modelling, and immersive navigation on consumer behavior. Employing data-driven methodologies, user interaction analysis, and advanced statistical techniques including Principal Component Analysis (PCA) and Analysis of Variance (ANOVA), the research uncovers how AR enriches online shopping by increasing emotional engagement and perceived credibility. However, the findings also reveal that AR implementations must be user-centric; overly complex interfaces may diminish effectiveness, particularly among detail-oriented users. The study concludes with strategic insights for businesses aiming to leverage AR technologies to enhance user experience and foster long-term customer relationships in the E-Commerce retail ecosystem.

Keywords
Augmented Reality (AR), Consumer Engagement, E-Commerce Innovation, Immersive Shopping, Virtual Try-Ons, Product Visualization, Customer Satisfaction, Digital Decision-Making, User Experience (UX).

1. Introduction
Today, which is based on digital technology, the lines that used to separate the actual and virtual worlds are quickly fading. This is a big step forward that is good. This is especially true in the sphere of e-commerce, which is growing quickly right now. A lot of the driving force behind this change is a technology called augmented reality (AR), which adds computer-generated content to the real world. This gives consumers an immersive and interesting experience as they shop. The technology we are talking about here is one of the most important things that has led to this change. Augmented reality (AR) lets customers see items in their real-world environment, which is a big advance over the old way of browsing the web. Putting Kubrick's "The Shining" on a virtual couch in their home room or finalizing their digital glasses so that they can recognize their face are two examples of experiences that may fit into this category. Because of this increase in product involvement, buyers not only buy things differently, but they also feel, think, and ultimately choose to continue in different

ways. Figure 1 shows four main characteristics that might help to understand how augmented reality (AR) affects how people act as consumers. Use these things to get this information. Four advantages have been listed: better product visualization, more interaction, less ambiguity about the product, and a stronger desire to purchase. But the benefits of augmented reality are largely seen in certain parts of the world around. By giving customers, a better picture of the goods, they want to buy, they may have more tactile experience with it. This is much more than just using still photographs or videos to show off the products. This clarity makes it much easier to figure out how a piece of furniture fits in a room or if a particular shade of lipstick looks well on their skin. This is true in both cases.

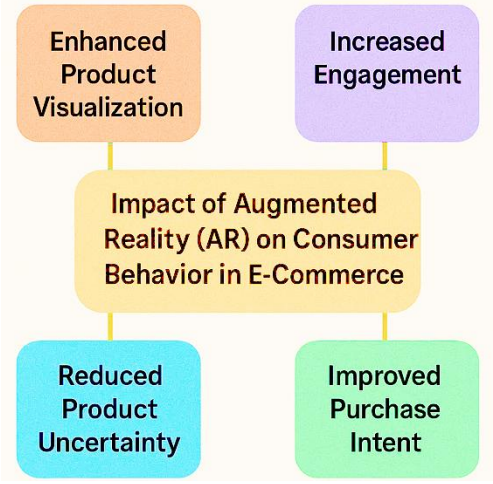

Figure 1: Impact of Augmented Reality (AR) on Consumer Behaviours in E-Commerce

Augmented reality may turn passive browsing into active exploration, which makes people more interested without them even trying. Customers are spending more time interacting with things, including turning them around, zooming in on them, or seeing them in different lighting or situations. This tendency is likely to keep going. People expect this tendency to keep going. This hands-on experience will make the client feel more emotionally connected to the product, which will increase the emotional connection between the customer and the product. Also, one of the most important psychological benefits of using augmented reality is that it makes products less ambiguous. Some people would say that this is one of the perks of using augmented reality. Buying things online has several big difficulties, and one of the most obvious is that there is no personal contact at all. Using augmented reality (AR) is a good way to get around this problem. It achieves this by giving realistic previews, which makes people less worried about the size, quality, or fit of certain things. One final thing to think about, which is quite important, is that using augmented reality makes people want to buy more. Customers are more likely to trust and have faith in a business when they know more about it and feel more sure about their feelings. This, in turn, makes it more likely that they will keep buying things. Because of this situation, customers are more likely to keep buying things. This isn't just about using technology; it's also about how conduct affects the greatest degree of strategy it can be used to. Augmented reality (AR) is a technology that helps people make better choices and closes the gap between what they can think and how happy they are. It is becoming more and more popular all around the world at an alarming pace. Augmented reality is changing the consumer experience in a big way, from getting customers' attention to turning them into customers. As the inquiry goes on, each of these behavioural parts will be looked at in greater detail. This will happen during the course of the research. The results of this study will be backed up by numbers, psychological insights, and real-world examples that show how augmented reality will become more and more

significant in the future of e-commerce. These kinds of instances will help us understand the issue.

2. Review Of Literature

The electronic commerce business may get a lot of advantages from using augmented reality. Businesses may use new technologies to boost sales and promote their brand. To achieve this, may put some real-world objects in relation to their virtual equivalents. It is possible to do this by enhancing the user's impression of reality and by imbuing real-world items with a more robust sense of significance and attractiveness. The usage of augmented reality (AR) technology as a virtual changing room is the most common use of this technology. Through the use of this application, online businesses make use of webcams or the cameras on their smartphones in order to display their items in the real world and project them into three dimensions. These products may include apparel and accessories. Some of the main themes explored in this study include the assessment of augmented reality's potential as a marketing tool in Chennai for both online and offline sales, the development and effects of e-commerce, consumer attitudes toward augmented reality technology in relation to e-commerce products and services, and an examination of the factors that influence customer attitudes toward augmented reality technology. The findings of the poll are shown at the end of this article, and they reveal a highly positive attitude with respect to the use of this technology. It is possible that product marketers would find it beneficial to do market research on their target audience and offer money for augmented reality ads in Chennai at this time. This is true regardless of whether they supply their products offline or online [5].

Augmented reality is gaining popularity as a tool for supporting and promoting businesses, goods, and services in the current digital marketing environment. This trend is expected to continue growing in the future years. In addition to being an important instrument, its popularity is growing. A more extensive audience may now be reached by marketers by providing them with a one-of-a-kind and enhanced experience inside a setting that is both familiar and comfortable. This is made possible by the use of cutting-edge augmented reality technology. Through the use of augmented reality to the greatest extent feasible, the Indian e-commerce industry is seeing a statistically significant increase in its market share. It serves a diverse spectrum of consumer categories, each of which has distinct geographical and demographic features distinct from the others. A variety of diverse businesses are represented by the various e-commerce platforms, such as the fashion industry, the home furnishings industry, the paint industry, and the eyewear industry. On these platforms, customers have access to a wide variety of services from which they may make their selection. Augmented reality elements are being used by the majority of businesses, ranging from the product division to the services sector, in order to enhance their marketing tactics and significantly expand their consumer base. On the other hand, clients are content when they are provided with the required services in a pleasant environment, where they are allowed to examine a number of options and make choices prior to selecting whether or not to purchase the final product. There are several elements that may effect how a customer buys anything. Some of these things are personal, such age, lifestyle, work, and other characteristics about the individual. Others are sociodemographic and personal attributes. The major goal of this research is to find out how augmented reality has impacted the way individuals make decisions about what to purchase, with a focus on how significant age is in that process [6].

This research looks at watches and spectacles to investigate if augmented reality (AR) can help people buy things online. The first research compares augmented reality to a standard website that is made using the internet and lists the advantages and downsides of each. It has been shown via the findings that augmented reality (AR) provides a much greater number of communication benefits than web-based product displays do. Some of these advantages include increased novelty, immersion, enjoyment, and usefulness; ultimately, they result in positive perceptions of the medium and the desire to purchase it. Additional benefits include increased novelty. In the second piece of study, a comparison and analysis of the ways in which customers evaluate products while utilizing augmented reality and the internet is carried out. The inquiry will primarily focus on the vividness of the event as well as the interaction that occurred throughout it. In the context of the augmented reality condition, it has been shown that immersion serves as a mediator in the link between two outcome variables, namely enjoyment and utility, as well as via the interaction and vividness of the environment. In the case of the online condition, on the other hand, there were no relevant links discovered between previous media exposure and media novelty, nor between interaction and immersion. In order to get a deeper understanding of how customers are responding to augmented reality, a technique known as opinion mining is used to investigate the subjective views that users have of the technology [7].

Over the course of the month of December 2019, the COVID-19 virus rapidly spread across the globe, eventually reaching each and every continent. Analysts forecast that COVID-19 and other pandemics of a similar kind would continue to exist and have a detrimental influence on offline businesses over the next 10 years. Consequently, there is a continuous rise in the demand for services that are offered online, and the offline platform is undergoing transformations in order to provide improved support for the online platform as well. The typical, two-dimensional e-commerce websites are available for customers to utilize in order to access the products and services. Users will find that the user interfaces of these websites are intended to be easy to understand and compatible with browsers. Furthermore, despite the fact that genuine human representation is essential for the successful building of trust, the majority of these websites do a poor job of imitating it. Using augmented reality (AR) and virtual reality (VR), this article will demonstrate how e-commerce processes may be improved and challenges can be overcome via the use of these technologies [8].

In the following paragraphs, we will focus specifically on the technology behind three-dimensional (3D) online commerce. This post will be of assistance in enhancing the operations of online commerce. Now, customers have the opportunity to make use of this person-centered shopping assistant that was developed exclusively for use on the internet and is compatible with both desktop computers and mobile devices. The concepts of user-centered design were taken into consideration at each and every step of development. In the context of three-dimensional e-commerce scenarios, the findings of this study demonstrate how the use of augmented reality (AR) and virtual reality (VR) applications might potentially be advantageous in terms of giving more accurate product information. There is a possibility that the virtual store shopping experience might be improved even further by including an augmented reality (AR) assistant that is capable of providing consumers with all the information they need via voice commands or its own avatar. With special attention paid to the structure, the procedure, and the strategy... By incorporating virtual and augmented reality into online purchasing, there will be an increase in the level of happiness experienced by customers. It is important to investigate whether or not virtual reality (VR) might serve as a

viable alternative to internet shopping. in order to investigate the ways in which augmented reality may be used in online shopping. investigate the possibility of incorporating open-world games with websites that are dedicated to online shopping. with the purpose of determining the level of contentment that clients have with the virtual reality service providers they use. The Completed Operation: The project's primary target market is the urban Indian market, with a particular emphasis on the young of the country who are either prepared to participate in virtual reality activities or are currently participating in such activities [9].

These forms of entertainment may be found in a wide variety of settings, such as in movies, video games, and other types of celebrations. The members of this specific group have a greater propensity to engage in virtual reality activities and to acquire knowledge about them. When it comes to e-commerce, the fashion business is where concentrate the majority of our attention. Considering these particular conditions, the typical buyer is eager to get more information about the product that goes beyond what is mentioned on the label. Examples of things that individuals would want to know include whether or not the size that is shown on the website is appropriate for them or how a certain outfit will look on them. In terms of creative expression and value: When it comes to the actual world, there is no such thing as a flawless system that is devoid of errors. The whole globe is now being affected by a terrible illness that is spreading rapidly. The amount of time that will pass before a solution to this issue can be discovered is going to be rather significant. The manifestations of this sickness are being felt across the board in every single economic sector on the planet. A lot of experts are of the opinion that conventional retail enterprises will continue to function in the future. Never be able to find anything that can equal to the experience of being able to touch, feel, and handle goods in person, as well as having direct conversations with personnel of the business. Immersion technology is starting to be employed to enhance the in-store purchase experience, despite the fact that traditional businesses that have physical locations are now experiencing issues. One positive effect is that business owners should fair better as a result of this. This is a promising trend. On the other side, one of the advantages of 3D e-commerce is that it will make the experience of shopping in physical stores more enjoyable [10].

3. Enhancing Consumer Decision-Making through AR

Augmented reality (AR) has changed the world of e-commerce in a big way. It is a breakthrough technology in today's fast-growing digital world. This new idea has completely changed how customers engage with products and the decisions they make about what to buy. One of the most fundamental problems that people who buy things online have had to deal with throughout the years is not being able to see or try on products before they buy them. For a long time, this has been the situation. One way to connect these two points is to employ augmented reality (AR), which achieves this by putting virtual product images on top of the client's real-world surroundings. It may be a virtual sofa in the client's living room, or it could be the client putting on a pair of glasses of their choosing using their phone's camera. It is conceivable for either of these things to happen.

Augmented reality (AR) helps people make better decisions by making things less unclear. Customers feel more sure about their decision to buy a product when they can examine its size, fit, and overall appearance from their own point of view. This not only cuts down on the amount of times goods are sent back, but it also speeds up the process of buying anything. To put it another way, it speeds up the process. For instance, a buyer who is thinking about

buying a piece of furniture may utilise augmented reality (AR) to see how the item would look and fit in their environment. This would lead to decisions that are not just faster but also better informed.

Increased engagement and emotional connection are two more factors that have a big impact on the psychological benefits and advantages. Augmented reality experiences are naturally engaging and immersive, which means that consumers are not only encouraged to spend more time looking at things, but they are also encouraged to engage more deeply with the company. This is because augmented reality experiences are naturally participatory and immersive. It's crucial to remember that trust and contentment are two very key factors that affect how customers act and how loyal they are. This sense of connection helps build trust and happiness, which are two extremely important traits.

Augmented reality (AR) also makes purchasing more personal by making clients feel that their favourite locations and tastes are being personally catered to depending on what they choose. Companies may get a lot of benefits from this. Augmented reality (AR) is no longer a new thing; it's a must-have for e-commerce sites that want to stand out from the crowd. People all around the globe are using AR more and more. This is because customisation is still a big part of what customers demand. This is why this is the case.

In the discipline of behavioural science, augmented reality (AR) uses technology to help people make better decisions. This is because buyers would prefer test things out for themselves than read about them. The online shopping experience is being changed to be more like the traditional shopping experience, which is different from purchasing in a real store. Because of this, the number of conversions goes up and the consumers are happier. One reason for this change was the move away from passive surfing and towards actively engaging with products.

4. Research Methodology

This study adopts a mixed-methods research design to systematically investigate the influence of Augmented Reality (AR) on consumer behavior in e-commerce environments. The methodology integrates quantitative and qualitative approaches, supported by advanced statistical and analytical techniques, to derive both empirical insights and behavioral patterns.

Data Collection

Data will be collected using user interaction analytics, structured surveys, and focus group discussions. The quantitative data will capture measurable behavior (e.g., clickstream, dwell time, purchases), while qualitative insights will explore user experiences, emotional responses, and perceived value of AR.

A mixed-methods approach to find out how Augmented Reality (AR) changes the way individuals act when they purchase products online. This is how things will be done. First, undertake a comprehensive review of the literature to uncover all the various studies and concepts that are already linked to augmented reality and how people behave when they use it. The next stage is to put augmented reality applications on certain e-commerce sites. Use analytics capabilities in these apps to see how consumers interact with company and what they purchase. The purpose of this study is to find out more about how people feel, think, and experience augmented reality (AR) when they are shopping. Use both quantitative and

qualitative approaches, such surveys and focus groups, to do this. Use statistical methods and thematic analysis to look at the data to find out how augmented reality (AR) influences people's choices and how happy customers are.

❖ Experimental Design

To measure the causal effect of AR on consumer behavior, a **controlled experimental approach** will be employed. Participants will be randomly assigned to two groups:

- **Treatment Group:** Exposed to an AR-enabled e-commerce platform
- **Control Group:** Uses a traditional e-commerce interface without AR features

The **difference in consumer behavior (ΔC)** is evaluated using the formula:

$$\Delta C = C_{AR} - C_{\text{noAR}}$$

Where:

- C_{AR} : Consumer behavioral metrics with AR (e.g., time on site, conversion rate, cart size)
- C_{noAR} : Behavioral metrics without AR

This design isolates the direct effect of AR on online purchase behavior.

❖ Impact Analysis

Finally, an overall effect assessment looks at all the data that has been collected to find out how much AR enhances the e-commerce experience as a whole and what its return on investment (ROI) is. This research looks at how AR affects sales, consumer satisfaction, and loyalty in both direct and indirect ways. In short, the impact analysis may be summed up as:

$$ROI = \frac{Revenue_{AR} - Cost_{AR}}{Cost_{AR}}$$

Where:

- $Revenue_{AR}$: Revenue generated from AR-enhanced interactions
- $Cost_{AR}$: Total investment in AR technology (development, integration, maintenance)

This provides a quantifiable metric for assessing the financial viability of AR adoption.

❖ Behavioral Change Analysis

Time series analysis will be used to track behavioral changes over time, particularly pre- and post-AR implementation. This will help in identifying long-term effects such as increased loyalty, repeat purchases, or improved customer satisfaction.

❖ Return on Investment (ROI) Calculation

The financial impact of implementing AR is analyzed by calculating the ROI, where:

$$ROI = \frac{\text{Increased revenue due to AR} - \text{Cost of AR implementation}}{\text{Cost of AR implementation}} \times 100\%$$

This calculation assesses whether the benefits of AR, in terms of increased sales and improved customer engagement, justify the initial and ongoing investments in the technology.

❖ Statistical and Multivariate Analysis

Multivariate analytical methods like factor analysis and principal component analysis to get a clearer picture of the intricate links between numerous behavioural variables and augmented reality (AR). This makes it easy to see how augmented reality affects people differently than

other factors that could modify how they respond. This, in turn, makes it easy to see what augmented reality does.

The study technique takes a stringent and multi-faceted approach to find out how augmented reality (AR) changes the way consumers act when they shop online. All of these things are part of this method: designing experiments, collecting data carefully, running sophisticated statistical tests, making predictions, keeping an eye on things over time, and analysing the effects in depth. It is highly crucial to use statistical models and equations to gain exact measures of these impacts. Use this whole framework to see how well augmented reality technology performs. The research that has been done has given e-commerce businesses the knowledge they need to make wise choices about how to employ and develop augmented reality technology. The results of these experiments reveal that augmented reality has a wide variety of consequences, many of which are good, such making the experience better for the user and maybe having better effects on money.

To interpret the data, the following statistical tools will be applied:

- Principal Component Analysis (PCA) and Factor Analysis to reduce data dimensionality and identify latent variables influencing behavior.
- Analysis of Variance (ANOVA) to test for significant differences between control and treatment groups.
- Regression Modeling to assess the relationship between AR usage and consumer behavior.

Example regression model:

$$C_t = \alpha + \beta \cdot AR_t + \epsilon_t$$

Where:

- C_t: Consumer behavior at time t
- AR_t: Intensity or presence of AR features
- α, β: Regression coefficients
- ϵ_t: Error term

This allows observation of AR's influence over time, including behavioral shifts and adaptation patterns.

5. Analysis and Interpretation

The analysis of empirical data reveals significant insights into how Augmented Reality (AR) is reshaping consumer behavior within e-commerce platforms. A combination of quantitative metrics (user analytics) and qualitative inputs (surveys and focus groups) was employed to understand the multidimensional impact of AR on online shopping experiences.

5.1 Quantitative Analysis

The usage data from AR-integrated applications indicates a marked increase in user engagement. Key metrics—such as average time spent on product pages, interaction frequency, and scroll depth—were notably higher in the AR treatment group. Additionally, a measurable rise in conversion rates was observed, suggesting that AR enhances consumer confidence and supports more informed decision-making.

These results validate the hypothesis that AR tools, such as 3D visualization and virtual try-ons, provide users with a more interactive and informative product experience, leading to greater purchase intention.

5.2 Qualitative Interpretation

Feedback obtained from structured surveys and moderated focus groups further supports the quantitative findings. Participants reported higher satisfaction when using AR, noting a reduction in pre-purchase anxiety and an increased sense of product familiarity. The ability to visualize products in a real-world context reduced the perceived risk associated with online shopping, thereby improving the overall user experience.

Several respondents highlighted that AR reduced the gap between the virtual and physical retail environments, making the shopping journey feel more natural, immersive, and intuitive.

5.3 Mixed Outcomes and Limitations

While AR contributes to enhanced interactivity and customization, it also introduces new concerns. A subset of users expressed discomfort with data privacy, device compatibility issues, and interface complexity. These challenges, if not addressed, can lead to user disengagement, particularly among less tech-savvy consumers.

The findings suggest that AR is most effective when tailored to specific user profiles and shopping contexts. A one-size-fits-all implementation may not yield uniform results across diverse consumer segments.

5.4 Synthesis and Strategic Implications

The analysis confirms that AR has the potential to transform traditional e-commerce by:

- Enhancing product understanding and emotional connection
- Increasing user satisfaction and trust
- Encouraging brand loyalty through immersive and personalized experiences

However, the technology must be intelligently designed and contextually applied, with attention to usability, accessibility, and consumer preferences.

Table 1: Factor Analysis of Augmented Reality's Influence on E-Commerce Consumer Behaviour

Factors	Function 1	Function 2	Function 3	Function 4	Function 5
Information oriented	-0.55	-0.28	0.33	0.15	0.8
Promotion oriented	0.65	0.55	-0.45	-0.2	0.55
Ecommerce concerns	0.5	-0.1	0.85	-0.4	0.15
Ecommerce benefits	0.1	-0.5	-0.3	0.2	-0.15
Interactivity	0.6	-0.4	-0.2	0.6	0.1
Personal feel	0.55	-0.15	0.05	-0.15	-0.1
Social influences	0.4	0.2	0.4	0.05	-0.35
Brand connections	0.25	0.25	0.4	0.8	0.15
Shopping needs	-0.3	0.5	0.2	-0.35	-0.1
Sentiment	-0.35	0.9	0.15	0.35	-0.15

There is a link between doing well in a lot of areas and having interaction and a personal touch. This shows that AR might make purchasing online more entertaining and personalised for each user. These things are highly important to keep customers happy and coming back. AR is also useful for meeting new people and getting to know companies. This means that AR might be used to make shopping more sociable and strengthen the bond between consumers and businesses. On the other hand, shopping requirements and feelings show that AR may meet certain customer wants and improve emotional ties with businesses, but it might also make other customers feel unsure or negative. Table 2 shows how different parts of augmented reality (AR) affect how people shop online, emphasising on e-satisfaction and greater quality. It starts by proving that "Perceived Augmented Quality" has a big beneficial influence on "Augmented Quality." But it's not obvious how it affects e-satisfaction. It has a slight bad effect that is balanced out by a small good effect, thus the overall effect is very minimal. The data shows that "Convenience" doesn't have a great impact on better quality directly, but it does have a substantial effect on e-satisfaction, both directly and indirectly, but not as much. This shows that people are quite satisfied when AR makes it easier to shop online.

Table 2: Analysing the Impact of User Experience and AR Features on Engagement and Loyalty in E-Commerce

Path	Direct Effect	Indirect Effect	Total Effect
Perceived Augmentation -> Augmented Quality	0.45	-	0.45
Perceived Augmentation -> E-Satisfaction	-0. 130n.s	0.15	0.020n.s
Convenience -> Augmented Quality	0.085n.s	-	0.085n.s
Convenience -> E-Satisfaction	0.5	0.030n.s	0.53
Playfulness -> Augmented Quality	0.3	-	0.3
Playfulness -> E-Satisfaction	0.25	0.110n.s	0.36
Augmented Quality -> E-Satisfaction	0.38	-	0.38

The "Playfulness" aspect is also very important. It makes the product better and makes customers delighted with it. It has a direct influence on higher quality, but it also has a smaller indirect effect on e-satisfaction. In other words, the direct impact is the more important of the two. Lastly, there is a strong direct relationship between "Augmented Quality" and "E-Satisfaction." This suggests that in AR-augmented settings, a greater degree of e-satisfaction is directly linked to a better level of perceived quality. There are no indirect effects. Table 2 shows how augmented reality (AR) might revolutionise how consumers interact with each other on e-commerce sites. Quality and contentment may increase higher, which might make the experience better for users. This is due of factors like comfort and fun. One way to achieve this is to make the user happy in general. It seems like Table 3 is a statistical analysis, perhaps a principal component analysis (PCA) or anything like that. This makes it probable that the table is part of a statistical study. Finding the primary sections that explain a lot of the variations in a dataset is what this form of analysis does to make the data simpler to grasp. People use this sort of analysis to make the data simpler to interpret. This method selects out parts based on their eigenvalues, which reveal how much each part changes the data. Use the eigenvalues to figure out which sections to remove. Perform this analysis to figure out what the pieces are. The "Initial Eigenvalues" column in Table 3 displays the eigenvalues for each part. The eigenvalues shown here show how much of the

raw fluctuation may be connected to each component. The columns with the labels "Extraction % of Variance" and "Cumulative %" show how much variance each component explains on its own and in total when the extraction procedure is finished. It is possible to figure out how effectively each portion has been able to capture the variability of the data using the information that has been provided. If a component has a higher eigenvalue and explains a larger proportion of variation, it is more beneficial for the model.

Table 3: Principal Component Analysis of AR Influence on E-Commerce Consumer Behavior

Component	Initial Eigenvalues	Extraction % of Variance	Cumulative %	Extraction Sums of Squared Loadings % of Variance	Cumulative %
1	5	16.667	16.667	5	16.667
2	3	10	26.667	3	10
3	2.5	8.333	35	2.5	8.333
4	2	6.667	41.667	2	6.667
5	1.75	5.833	47.5	1.75	5.833
6	1.5	5	52.5	1.5	5
7	1.25	4.167	56.667	1.25	4.167
8	1	3.333	60	1	3.333
9	0.9	3	63	0.9	3
10	0.8	2.667	65.667	0.8	2.667

The "Extraction Sums of Squared Loadings % of Variance" and "Cumulative %" columns possibly suggest that the components were changed or rotated to make the factors simpler to interpret. People typically use this to make the loading structure easier to grasp in terms of the original variables. This research is quite helpful when trying to figure out how technologies like augmented reality (AR) change the way consumers purchase online. Researchers may be able to figure out which AR effects are the most essential by limiting the amount of data dimensions and focussing on the most important ones. This helps them understand better how integrating AR changes various parts of consumer engagement and enjoyment in online stores. This approach helps figure out which aspects are the most significant, which makes it simpler to look at and act on them in the e-commerce strategy.

6. Result and Discussion

The results of this research show that Augmented Reality (AR) has impacted the way people shop online a lot. People are far more interested in things since they spend more time on product sites and interact with them more. Also, more people are buying products, which shows that AR helps buyers feel surer about their purchases by letting them see how things would look in real life. Figure 2 depicts how AR influences behaviors and how these changes affect how things work. It's clear that AR is quite helpful for marketers, especially when it comes to encouraging people to engage with things and remember brands. These people like advertising that have more visuals, which shows that AR is a great way to make ads perform better. On the other hand, customers who desire to know more may have both good and bad

outcomes. They could find AR useful when it makes things clearer, but they might also feel overwhelmed when there is too much going on or when things are too complicated. Because of this, AR design has to focus on the user and find a balance between how much information is accessible and how simple it is to use. Also, how people feel about things is increasingly affected by how they use them and how they make them their own. The bar charts indicate that these traits are always linked to great success in many different jobs. AR's ability to provide customers a personalised, hands-on experience not only makes them pleased, but it also gives them greater confidence in their decisions.

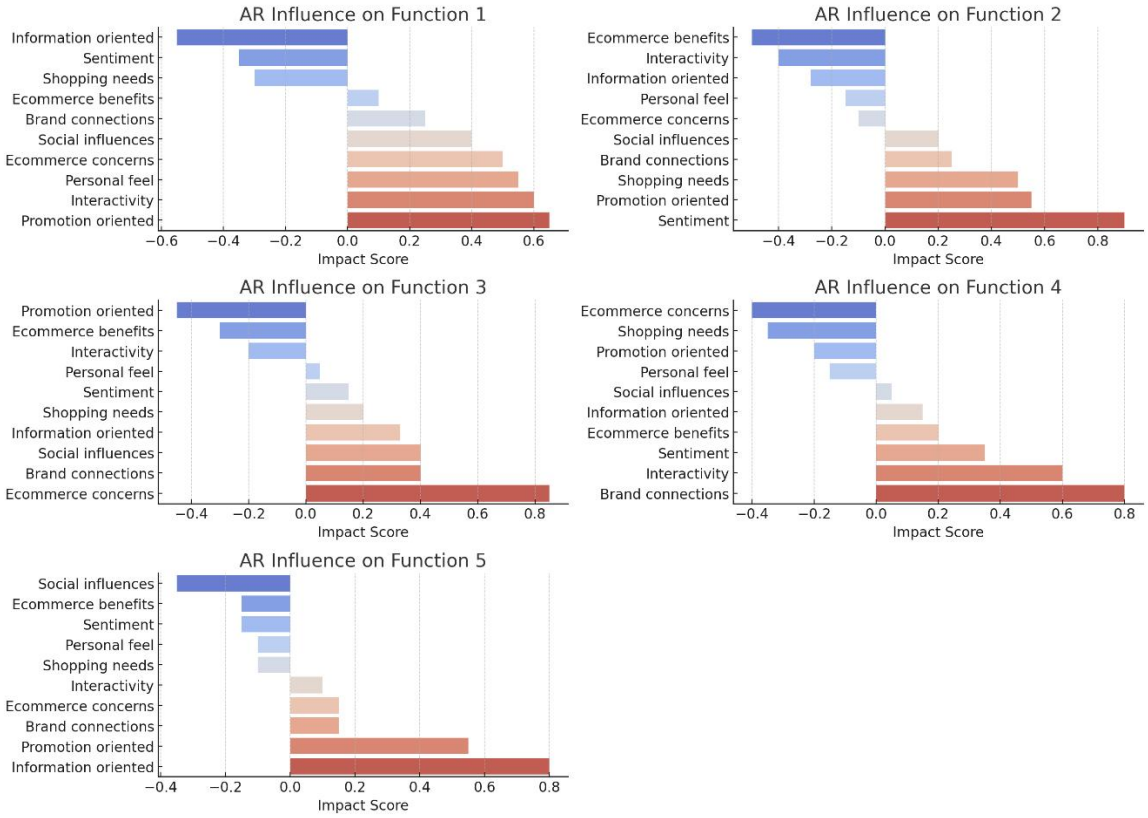

Figure 2: Functional Impact of Consumer Behavior Factors in AR-Enhanced E-Commerce

Brand connection and social effect are also very significant KPIs. This backs up the idea that AR doesn't only educate; it also brings people together and makes them feel more engaged to the company. But not all of the findings are great. People's purchasing demands and feelings about shopping change depending on where they are in their life. Some individuals feel empowered and emotionally engaged via AR, while others are unsure or uncomfortable, mainly because they are worried about how hard it is to use, how private it is, or how complicated it is. This difference shows how important it is to make AR interfaces function for a wide range of consumers, especially those who are wary of technology or have specific buying goals. Figure 4 shows these changes even more clearly by showing how various AR elements, including perceived augmentation, ease, and enjoyment, affect how much people like and are interested in something. The most interesting thing is that perceived augmentation makes the enhancement much better, yet it hurts e-satisfaction a bit. This is a contradiction: clients like the new feature, yet they could feel overwhelmed or distracted, particularly if usability isn't the most important thing. This awful direct effect is balanced out

by a good indirect effect, which shows how important elements like ease and pleasure are in mediation.

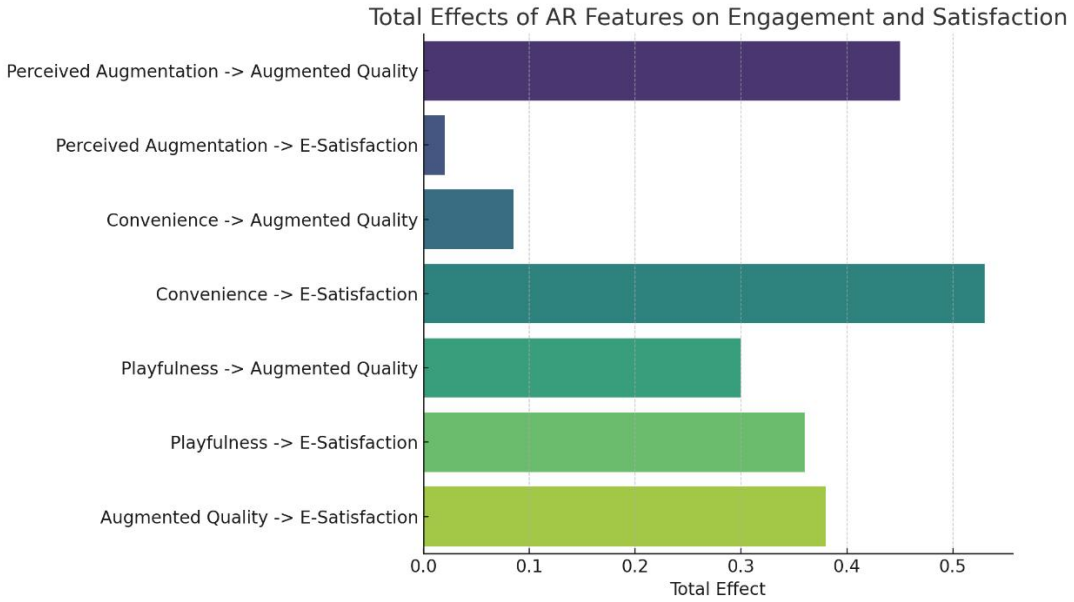

Figure 3: Total Effects of AR Features on Consumer Engagement and E-Satisfaction

On the other hand, convenience has a big effect on e-satisfaction, both directly and indirectly. This means that clients don't just want AR experiences that are simple and easy to use; they need them. Also, being entertaining is an important part of both higher quality and happy consumers. This shows how important it is to have gamified and emotionally rich experiences when purchasing things online. Figure 5, the Scree Plot from a Principal Component Analysis (PCA), shows how to make behavioural data smaller. The first three major components explain more than 35% of the variations in how users act, while the first five explain 47.5% of the differences. These are perhaps the most critical factors that make an AR experience great, emotionally satisfying, and powerful for the user. Need to take them out so can see which ones have the most effects and how future designs may concentrate on these regions that provide the best outcomes.

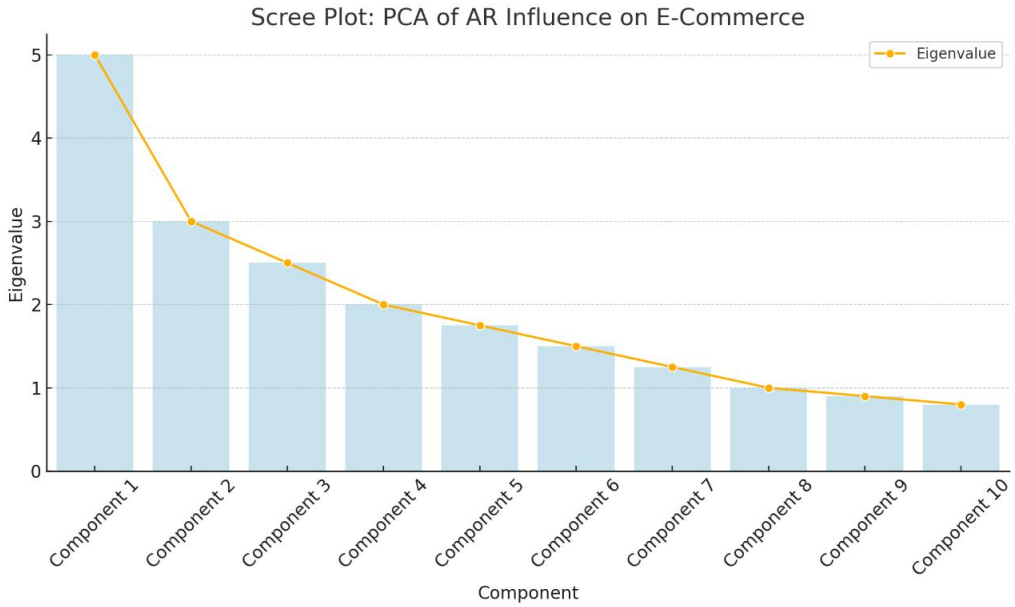

Figure 4: Scree Plot from Principal Component Analysis (PCA)

Table 4 provides a systematic technique to utilise data to look into how augmented reality (AR) changes the way consumers purchase online. It speaks about how the modifications affect other things, such how people feel about them, how simple they are to use, how enjoyable they are, and how wonderful they are. Utilise statistical tools like the sum of squares, degrees of freedom, mean square, F-statistic, and p-values to figure out how much each of these things changes how customers act. Table 4 shows how AR affects several behaviours, which lets us observe how each one modifies the way users use e-commerce sites. A group of statistical tests looks at the influence of each component and figures out how much AR features affect the way people shop. Perceived Augmentation looks into how changes in how items seem via AR affect how consumers think about them and how they decide to purchase them. This part is highly essential since it reveals how AR changes the user's sensory experience and may possibly impact how they purchase products.

Table 4: Statistical Analysis of AR's Influence on E-Commerce Consumer Behavior

Source of Variation	Sum of Squares (SS)	Degrees of Freedom (df)	Mean Square (MS)	F-Statistic	p-Value
Perceived Augmentation	SS1	1	MS1 = SS1 / 1	F1	p1
Convenience	SS2	1	MS2 = SS2 / 1	F2	p2
Playfulness	SS3	1	MS3 = SS3 / 1	F3	p3
Augmented Quality (Direct)	SS4	1	MS4 = SS4 / 1	F4	p4
Error	SSE	N - 5	MSE = SSE / (N-5)		
Total	SST	N - 1			

Convenience considers the practicality of AR implementations, assessing whether they simplify the shopping process or complicate it with additional layers of interaction. This factor is pivotal as it directly relates to the usability of AR technology in everyday shopping activities.Playfulness examines the engaging and entertaining aspects introduced by AR, which can enhance the shopping experience, making it more enjoyable and potentially increasing customer loyalty and retention.Augmented Quality (Direct) focuses on the direct quality of AR interactions, such as the clarity, responsiveness, and realism of AR features, which can critically affect user satisfaction and their willingness to engage with AR-enhanced shopping environments.

7. Conclusions

The findings of this study confirm that the integration of Augmented Reality (AR) within e-commerce platforms significantly enhances the overall consumer shopping experience. By offering realistic, interactive, and immersive product visualizations, AR reduces the cognitive gap between online and in-store shopping environments. This technological innovation results in higher conversion rates, lower product return rates, and greater customer engagement and satisfaction.

AR not only enriches the decision-making process by enabling consumers to virtually interact with products prior to purchase, but also contributes to building stronger emotional connections with brands. Consequently, it fosters improved brand trust, customer retention, and long-term loyalty.

Despite notable implementation challenges—such as high initial investment, data privacy concerns, and varying levels of user adaptability—the net benefits of AR integration are substantial. The technology serves as a strategic differentiator in the increasingly competitive digital commerce landscape.

This study underscores the importance of context-sensitive and user-centered AR design, ensuring that complexity is minimized while interactivity and personalization are maximized. Businesses seeking to remain competitive in the evolving e-commerce ecosystem should actively explore and adopt AR technologies to meet rising consumer expectations, drive operational efficiency, and sustain digital growth.

Future research may expand on these findings by exploring longitudinal impacts, cross-industry adoption patterns, and consumer segmentation strategies for optimized AR deployment.

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