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Research Article

"Beyond Standard Sizing: A 3D Revolution in Online Apparel Retail for Personalized and Precise Fit"

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ABSTRACT

Three-dimensional body scanning is a non-contact method of measuring the human body. This process is highly accurate, quick, efficient, and reproducible. According to Bragança, Arezes, Carvalho, and Ashdown, 2016, clothes that are not designed taking into consideration the dynamic postures greatly affect the users' feeling of comfort and performance. 3D body scanning technology has great potential for successfully being employed in online apparel-selling applications. However, the successful implementation of this technology depends on the acceptance by consumers. While it has not acquired mass adoption, mobile scanning applications promise to bring benefits straightforwardly to the customer.

This research was undertaken on 315 respondents from Ahmedabad. Questions related to problems faced while buying perfect-fit garments online, the need for more personalized and precise fit options for online apparel shopping, and major reasons for returning or exchanging the garments as well as leading to reluctance towards expensive garment purchases online, were addressed. In addition, the concept of 3D body scanning technology in online apparel-selling apps solving the above-mentioned problems was explored. Likert scale questions pertaining to the views of the respondents towards 3D body scanning technology in solving the return/exchange issues, providing the perfect fit, helping in choosing the right dress were also asked. The responses were classified into 2 categories: Optimizing Shopping Experience with 3D Technology and Promoting Sustainability in Online Apparel Retail

Studies show that automated 3D body scanners can effectively and quickly take precise measurements of the human body and produce accurate, to-scale representations. The integration of 3D body scanning technology has emerged as a pivotal link between traditional craftsmanship and computer-aided design, offering promising prospects for enhancing precision in clothing design and production. Anticipated benefits from the implementation of this technology include heightened consumer satisfaction through personalized sizing and a consequential reduction in commercial waste attributed to the decreased frequency of returns due to ill-fitting garments.

Keywords: Apparel Ecommerce, 3D Body Scanning Technology, Consumer Acceptance, Mobile Scanning Applications, Precision in Clothing Design, Commercial Waste Reduction

1. Introduction

In the ever-evolving world of online apparel retail, there is a growing need for personalized and precise fit. For consumers, finding the perfect fit can often be a cumbersome, multi-step ordeal, involving ordering two sizes and initiating a cycle of deliveries and returns. According to Alpha wise Morgan Stanley report 2018 product sizing and return processes represent significant obstacles for online apparel shoppers. Consumers are increasingly seeking garments that are tailored to their exact measurements, taking into account not only their body shape and size but also their unique preferences and asymmetry (Pantano et al., 2017). This shift

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towards customization and individualization in online apparel shopping is driven by advancements in technology, such as 3D scanning and modelling. These technologies allow for the creation of virtual fitting rooms and personalized try-on experiences, where consumers can see how different garments will look and fit on their bodies. This revolution in online apparel retail has the potential to greatly enhance the shopping experience for consumers, providing them with a level of customization and accuracy that was previously unavailable (Pantano et al., 2017). The growing adoption of sizing apps and augmented reality (AR) presents a solution to the significant challenges encountered by online shoppers. This trend has the potential to boost sales and revolutionize the economic strategies of apparel brands (Alpha wise, Morgan Stanley Research May 2018)

Online shopping for clothing often results in ill-fitting items due to size discrepancies, leading to numerous challenges. Customers face frustration, increased return rates, and environmental concerns stemming from excessive shipping and waste. However, integrating 3D technology for personalized fit solutions can revolutionize the online shopping experience. By allowing customers to virtually try on garments, this technology ensures precise measurements, reducing returns, enhancing customer satisfaction, and boosting sales. Moreover, it promotes sustainability by minimizing unnecessary shipping and returns, contributing to environmental preservation. Overall, 3D technology addresses size issues, improves customer experience, and supports sustainable practices, reshaping the future of online fashion retail. In the ever-evolving realm of online apparel retail, the integration of 3D technology has emerged as a transformative force, offering enhanced personalized and precise fit experiences beyond traditional standard sizing practices. The efficacy of 3D scanners in facilitating confident purchases of expensive clothing and reducing returns underscores the pivotal role of this technology in reshaping consumer behaviour and expectations. 3D scanners not only enhance the overall shopping experience but also contribute to greater consumer satisfaction and loyalty. 3D body-scanning significantly reduces online retailer's rate of return to 10 % and wide spreading the benefit to reducing the customer cost to close 20 % (Ruddell, 2018)

From the numerous images generated by the scanner, the scanner and measurement extraction software disseminate thousands of automatically extracted measurements of individuals from head to toe and send it to the manufacturer to create a custom fit measurement for its customers. Customization needs to cater masses to meet the economies of scale and to stand with the sustainability factor. These precise scanned measurements could be used as an effective database to be used by the manufacturers to understand the body types and be aware of standardization possibilities within it, rather than fitting the Indian odd-sized ones to a standard west-based size and fitting them to those standardized numbers.

Samshek is one such homegrown brand that identifies the urgent call for connecting technology with fashion. The brand addresses the major issue of fashion brands' sizing and sustainability and thereby attempts to contribute positively towards approximately 3.8 billion fashion clothing being dumped annually. Further to add brands like Fable Street, Bombay Shirt Company, Tailorman, Vitruvian and Indi-Go use 3D body-scanning for various purposes such as custom fitting, virtual try-on experiences, and accurate sizing. Brands like Myntra, Bewakoof, and Yepme use interactive and immersive features of integrated augmented reality (AR) to enhance the shopping experience of its customers in India.

The combination of 3D technology, online retailing, personalized fit, and sustainability heralds a new age in the fashion industry. By embracing digitalization and leveraging cutting-edge technologies, retailers can redefine the customer experience, foster sustainability, and unlock new avenues for growth and innovation. As the fashion landscape continues to evolve, research endeavours play a crucial role in unravelling the potential of 3D technology to shape the future of apparel retailing.

Although adoption may remain a few years down the line, the implementation of 3D body scanning technology holds the potential for far-reaching effects beyond the realm of clothing. It could significantly influence various retail sectors, including mall operators, real estate investment trusts, and shipping and logistics companies. However, the adoption of 3D scanning technology faces its own challenges, particularly concerning customer reluctance to share potentially sensitive bodily data and the need for assurance that the data collected is securely managed by the entities handling it.

The effectiveness of 3D technology lies in its ability to capture precise body measurements, enabling retailers to offer customized apparel tailored to individual preferences and dimensions. Unlike traditional sizing methods, which often result in ill-fitting garments and high return rates, 3D scanning technology ensures a more accurate and personalized fit experience for consumers. By providing shoppers with the confidence that their purchases will align perfectly with their unique body shapes. In the rapidly evolving landscape of fashion retail, the integration of 3D technology has emerged as a transformative force, revolutionizing the way apparel is designed, customized, and marketed online.

Sadia Idrees, Simeon Gill & Gianpaolo Vignali (2023) Mobile 3D body scanning applications: a review of contact-free AI body measuring apparel solutions, The Journal of The Textile Institute and D. Ram, B. Roy and V. Soni, "A Review on Virtual Reality for 3D Virtual Trial Room," 2022 IEEE World Conference on Applied Intelligence and Computing (AIC), Sonbhadra, India, 2022 underscore the pivotal role of 3D body scanning and virtual try-on technology in enhancing the online shopping experience. These technologies enable customers to visualize garments in a virtual environment, promoting personalized fit and reducing the likelihood of returns. Bugao Xu and Yaxiong Huang in 3D Technology for Apparel Mass Customization, Rotary Body Scanning, January 2003, delve into the implications of 3D technology for mass customization.

By leveraging 3D body scanning and printing technologies, retailers can offer customized apparel tailored to individual body measurements, thereby enhancing customer satisfaction and loyalty.
The theme of sustainability also permeates several studies. "The Role of 3D Body Scanning in Sustainable Fashion" and "Sustainable Apparel Mass Customization in the Age of Industry 4.0" explore how 3D technology can contribute to sustainable practices in the fashion industry. Through efficient inventory management, waste reduction, and optimized production processes, 3D technology aligns with the principles of environmental stewardship and social responsibility.
Moreover, the synthesis of digitalization, mass customization, and sustainability is evident in papers like "Digitalization in Apparel Supply Chain" and "Sustainability and Mass Customization in the Apparel Industry." These studies underscore the potential of 3D technology to drive innovation across the apparel supply chain, from design and production to distribution and marketing.
In conclusion, the amalgamation of 3D technology, online retailing, personalized fit, and sustainability heralds a new era in the fashion industry. By embracing digitalization and leveraging cutting-edge technologies, retailers can redefine the customer experience, foster sustainability, and unlock new avenues for growth and innovation. As the fashion landscape continues to evolve, research endeavors play a crucial role in unraveling the potential of 3D technology to shape the future of apparel retailing.
The online apparel retail industry is continuously evolving, with advancements in technology driving new possibilities for a personalized and precise fit. Traditional standard sizing has long been the norm in online clothing shopping, but it often fails to accurately accommodate the diverse body types and preferences of consumers.

2. Literature Review

Three-dimensional body scanning is a non-contact method of measuring the human body. This process is highly accurate, quick, efficient, and reproducible (Braganca, Arezes, & Carvalho, 2015; Gill, 2015). 3D body scanning technology had great potential for successfully being employed in the apparel industry. Research suggested that men and women were likely to adopt body scanning technology (Drake, 2007). These concerns could indicate that there is a difference in the type of body scanning technology that will be preferred by men versus women. A recent 3D body scanning technology from Size Stream, 2019 was designed to accurately capture and digitize the human body's shape and measurements. These systems utilize advanced sensors and cameras to create precise 3D models of individuals quickly and efficiently in which participants wore a scan suit and used a mobile phone's camera with an app to perform scans (Size Stream, 2019). Firms have understood the need of custom-fit clothing, but today the challenge is to understand customer acceptance, Davis's TAM framework to understand consumers' preferences for body scanners would provide valuable insights for technology developers and retailers in designing and marketing these products effectively (Davis,1989). The impact of individual factors on consumer reluctance to make purchases in online settings, as well as their inclination towards purchasing custom-made clothing.
Further, the assessment of the impact of individual factors on consumer reluctance to make purchases in online settings, as well as their inclination toward purchasing custom-made clothing was also examined (Žuraj et al., 2017). The paper delves into the analysis of individual factors that affect non-purchasing behavior in online environments and the willingness of consumers to buy custom-made apparel. The study particularly focuses on the influence of advanced 3D technology, such as 3D body scanning and automated Computer-Aided Design (CAD) software, on various aspects like fit, visualization, and manufacturing processes related to custom-made apparel in online retail settings. The author explores how these technological advancements contribute to enhancing the fit and visualization of custom-made clothing, which aligns closely with the emerging trend of leveraging 3D technology for personalized and precise fit in online apparel retail. By integrating 3D body scanning and automated CAD software, online stores can offer tailored solutions to consumers, potentially mitigating issues related to fit and satisfaction with standard sizing.
Few studies were attempted to study consumer perceptions regarding apparel integrated with 3D printing technology, to understand how consumers perceive apparel created using integrated 3D printing technology. Also, a Functional, Expressive, and Aesthetic (FEA) perspective was considered to analyze consumer perceptions of such apparel. Factors like comfort, durability, design flexibility, and customization options enabled by 3D printing technology were also considered in the study (Tianyu Cui, Veena Chattaraman, and Lily Sun, 2021). These virtual-try-on apps possess capabilities of revolutionizing the consumer journey by offering tailored solutions, ultimately redefining the dynamics of mobile commerce in the apparel industry (Sohn et al. 2020). These applications can reshape the consumer experience as it offers tailored solutions, mobile-commerce engagement (Tawira & Ivanov, 2022)
The use of augmented reality (AR) technology while evaluating garments while shopping online make the experience satisfactory and helps in improving consumer decision making, it further provides consumer insights for the retailers to better perform in the realm of fashion e-commerce (Baytar, Te-Lin Chung, and Eonyou Shin, 2020). An extensive study to understand 3D scanning systems exploring the technology, application and challenges of the system. Further the light was thrown on other capabilities of the system and its significance in cross industries like healthcare, apparel designing sectors, anthropometry and ergonomics (Weiguo Zhang, Yan Li, and Yanjun Qian, 2013).

A comprehensive overview of the design and implementation of a system aimed at enhancing the efficiency and accuracy of mass customization processes within the apparel industry. The emphasis on this system's role in addressing consumer demand for personalized garments is particularly noteworthy. By detailing the design and implementation process, the study offers valuable insights into how technology can be leveraged to meet evolving consumer preferences in the apparel sector. Overall, the study contributes to a deeper understanding of the intersection between technology, mass customization, and consumer demand for personalized products within the apparel industry (X. Liu, A.Y.C. Nee, and C.F. Chen, 2004)

The integration of body scanning techniques to achieve a personalized fit, consequently enhancing the overall online apparel shopping experience. Addressing the intersection of body scanning technology and apparel e-commerce brings invaluable insights into the potential of 3D garment design to revolutionize the way consumers interact with online retail platforms (Xi Chen, Lusheng Gu, and Xuedong Tian, 2017). The development and implementation of virtual try-on systems for online apparel shopping highlight the potential to revolutionize the way consumers interact with online retail platforms. It enhances customer satisfaction, reduces returns, and increases overall sales within the online apparel industry. It enables customers to visualize how garments will look and fit on their bodies before making a purchase, virtual try-on systems play a pivotal role in bridging the gap between the online and offline shopping experiences (J. Li, X. Liu, and A.Y.C. Nee, 2010). Technology can potentially boost online sales by improving personalized fit and customer satisfaction (Marianne Bickle, Janet Eckford, and Ian Ferris, 2014).

The 3D virtual Try-on technology in online apparel shopping renders techniques to create realistic virtual representations of garments, which users can then interact with in a virtual environment, (Jintu Fan, and Sijing You, 2019). 3D body scanning and printing technologies are revolutionizing the traditional apparel retail model by offering tailored solutions that cater to individual preferences and body shapes but comes with cost constraints, technology limitations and also restrictions to customer acceptance too thus a guide offered to industry stake holders helps in proper navigation to the rapidly evolving landscapes (Fiona Dieffenbacher and Hua Xiao, 2015).

A mix-method approach combining Qualitative and Quantitative research to understand the Augmented Reality's impact on consumer purchase intentions, perception, and attitude as this impacted on perceived usefulness for the customers, ease of use of technology, leading to perceived enjoyment while using the technology in apparel retailing context (Yuen-Ying Chan, Vignesh Yoganathan, and Ting Ting Cheng, 2021). The Journal of fashion marketing and Management explores 3D body scanning technology with a consumer-centric approach and examines its influences on consumer perception fit, satisfaction and intention to buy.

The huge data hence accumulated uncovers consumer insights driving positive outcomes for both retailers as well as customers (Kyung Hoon Yang and So Yeon Park, 2017). AR technology does have challenges in integrating with retail, a shift from traditional ways to modern retailing provides interactive and immersive features like instore navigation, virtual try-on experiences and product visualization, and this leads to customer engagement, increasing conversion rates, and reducing product returns leading to business growth (Nandini Gupta and Akhilendra Pratap Singh, 2019).

The integration of AR with other emerging technologies, such as artificial intelligence (AI) and Internet of Things (IoT) leads to better enhancement in the concept of revamping the online retail outlook. Apart from customer engagement and enhanced shopping experience the AR augments brand perception (Mohamad Taleb, Patrick Mikalef, and Adamantia Pateli, 2018).

A 3D body scanning does have impact on supply chain management, inventory optimization and sustainability initiatives in fashion industry. In the industry 4.0 era, sustainable apparel and mass customization practices leads to technology advancement emphasizing environmental and social considerations (Yunsong Gao, Young-A Lee, and Jinwoo Park, 2020). An efficient customization process could be accomplished through personalized fit and virtual garment simulation process (Tsan-Ming Choi, Yong Yu, and Xin Zhao, 2012)

3. Research Objectives

- Assess the effectiveness of 3D technology in enhancing personalized and precise fit experiences in online apparel retail beyond traditional standard sizing practices
- To examine the efficacy of 3D scanners in facilitating confident purchases of expensive clothing and also reducing returns.
- Investigate consumer perceptions and preferences regarding adopting 3D technology for personalized fit solutions in the online apparel retail sector.
- To investigate the potential influence of 3D technology on enhancing shopper satisfaction, increasing sales, and establishing 3D scanners as pivotal components of the online retail landscape.
- Evaluate the sustainability implications and consumer consciousness of integrating 3D technology for personalized fit experiences in online apparel retail compared to traditional sizing methods.

4. Research Methodology

The research employed a non-probability convenience sampling method, engaging 317 respondents in a comprehensive survey. The questionnaire comprised two sections. The initial segment encompassed demographic inquiries regarding age, gender, and occupation, alongside assessments of 3D technology's efficacy in enhancing personalized and precise fit experiences in online apparel retail. The subsequent section delved into the efficacy of 3D scanners in fostering confident purchases, reducing returns, and gauging consumer perceptions on 3D technology adoption, its impact on shopper satisfaction and sales, and the sustainability aspects of integrating 3D technology in online apparel retail.
The study results confirmed that the Cronbach's alpha values of the variables were above 0.950for both scales well above the threshold of 0.60 (Pallant, 2013). The principal axis factoring method along with the ANOVA test was applied to generate statistical interpretations.

5. Data Analysis

The data analysis utilized SPSS 22.0 for statistical processing. An electronic questionnaire, constructed on Google, facilitated data collection. A total of 317 participant responses were captured. Descriptive statistics of the respondents were examined using the SPSS software, producing analytical outcomes. Descriptive analysis focused on the central tendency (mean) and variability (standard deviation) of the data, while inferential analysis encompassed ANOVA (One-way Analysis of Variance) and Exploratory Factor Analysis (EFA). ANOVA explored potential differences in respondent groups' perceptions regarding the adoption of 3D technology for personalized fit solutions in the online apparel retail sector Exploratory Factor Analysis (EFA) explores the dimensions encompassing 'Optimizing Shopping Experience with 3D Technology' and 'Promoting Sustainability in Online Apparel Retail'. EFA serves as a preliminary step for Confirmatory Factor Analysis (CFA). Principal components analysis scrutinized the factors within this study, employing Varimax rotation as the rotation method. The Kaiser-Meyer-Olkin-Bartlett-Sphericity tests assessed the suitability of the factor analysis, with a recommended KMO (Kaiser-Meier-Olkin) coefficient exceeding 0.7. Bartlett's test determined the significance of the correlation matrix compared to zero. Cronbach's alpha coefficients evaluated the internal consistency reliability. By exploring these trends, the paper provided valuable insights into the effectiveness of 3D technology in enhancing personalized and precise fit experiences in online apparel retail beyond traditional standard sizing practices.

5.1 Descriptive Statistics

The table 1 below shows the demographic details of the respondents

Table 1: Demographic details of the respondents		
Age	**Frequency**	**Percent**
Prefer not to say	2	.6
16-25	72	22.7
25-35	51	16.1
35-45	75	23.7
45-55	54	17.0
55 and above	63	19.9
Total	317	100.0
Gender	**Frequency**	**Percent**
Prefer not to say	2	.6
Male	126	39.7
Female	189	59.6
Total	317	100.0
Occupation	**Frequency**	**Percent**
Prefer not to say	2	.6
Students	48	15.1
Salaried	135	42.6
Business	66	20.8
Housewife	33	10.4
Retired	33	10.4
Total	317	100.0
How often do you shop for apparel online?	**Frequency**	**Percent**
Prefer not to say	2	.6
Rarely	33	10.4
Often	210	66.2
Occasionally	72	22.7
Total	317	100.0
Have you ever struggled to find the right fit when shopping for clothing online?	**Frequency**	**Percent**
Yes, all the time	245	77.28
No	30	9.4
Occasionally	42	13.24

When questioned about the importance of having and wearing perfectly fitting clothes, the most prevalent response highlighted the recurring challenge of finding well-fitting clothes online. The summary of the responses is mentioned in the table 2 below.

Table 2: How much value do you place on having perfectly fitting clothing?		
	Frequency	Percent
Fit is everything - I won't settle for anything less than perfect	36	11.4
I'm willing to pay extra for clothing that fits me like a glove	44	13.9
Having a precise fit is a top factor in my purchasing decision	36	11.4
I struggle to find clothing that fits well, so it's extremely valuable to me	51	16.1
I have a hard time finding standard sizes that fit, so personalized fit is priceless to me	43	13.6
I'm open to trying new technology for a more accurate fit in online shopping	34	10.7
Having perfectly fitting clothing gives me confidence and is worth the investment	34	10.7
I believe personalized fit is the future of online apparel retail	39	12.3
Total	317	100.0

When queried about the appeal of a 3D technology-based sizing system for online apparel shopping, whether the utilization of 3D technology in online apparel retail would enhance shopping convenience and efficiency, and if respondents would be inclined to purchase from an online retailer providing personalized and precise fit options through 3D technology, respondents expressed the following.
Nearly 82% of respondents agreed with the notion that a 3D technology-based sizing system would be appealing for their online apparel shopping experience. Additionally, approximately 89% of participants indicated that implementing 3D technology in online apparel retail would enhance shopping convenience and efficiency. Similarly, the same percentage of respondents stated that they were more inclined to purchase from retailers offering personalized and precise fit options for online clothing shopping through 3D technology.

Table 3: Respondents' view on personalized and precise fit options through 3D technology		
Would a 3D technology-based sizing system appeal to you for online apparel shopping?		
	Frequency	Percent
No	59	18.61
Yes	120	37.84
Definitely	138	43.53
Total	317	100
Do you think that the use of 3D technology for online apparel retail would make the shopping experience more convenient and efficient?		
	Frequency	Percent
No	35	11.0
Yes	210	66.2
Definitely	72	22.7
Total	317	100
Will you be more likely to purchase from a retailer that offers a personalized and precise fit option for online clothing shopping through 3D technology?		
	Frequency	Percent
No	35	11.04
Yes	210	66.25
Definitely	72	22.71
Total	317	100

To assess the effectiveness of 3D technology in improving personalized and precise fit experiences in online apparel retail compared to traditional standard sizing practices, we utilized the mean and standard deviation of the variables. A higher mean indicated a higher ranking. In cases where two variables shared the same mean, those with smaller standard deviations were ranked higher. Table 4 illustrates the ranking accordingly.
The most critical factor for the effectiveness of 3D technology in enhancing personalized and precise fit experiences in online apparel retail beyond traditional standard sizing practices was:
3-D scanners help you to buy expensive clothes fearlessly and Consumers should actively support online apparel retailers that prioritize sustainability alongside the implementation of 3D technology for personalized and precise fitting. Both had the highest mean of 4.45. The lowest mean was of the statement: Virtual 3D Avatar (view from various angles, zoom, rotation, spin) will be favoured. Below are mentioned the 14 statements with mean values between 1.86 and 4.45

Table 4: Mean Ranking of the statements			
	Statements	Mean	Std. Deviation
1	3-D scanners help you to buy expensive clothes fearlessly.	4.45	1
2	Consumers should actively support online apparel retailers that prioritize sustainability alongside the implementation of 3D technology for personalized and precise fitting	4.45	1
3	3D Scanner would be useful for plus size and tall people who don't fit in regular fitting clothes.	4.44	1.05
4	I believe that integrating sustainability practices within the 3D revolution of online apparel retail for personalized and precise fit is crucial for environmental preservation.	4.43	1.07
5	Body measurements for customization will be accurate	4.43	1.04
6	3D Scanner will soon become an important feature of e-commerce websites.	4.43	1.07
7	Virtual try-on will be delightful for shoppers	4.38	0.94
8	Return due to ill-fit will be reduced using a 3-D scanner.	4.33	1
9	The virtual dressing room will give complete satisfaction and enhance the online shopping experience.	4.16	1
10	The 3-D scanner will resolve the size issue.	4.15	0.97
11	The adoption of 3D technology in online apparel retail, focused on personalized and precise fit, should prioritize sustainable materials and production processes.	1.96	1.04
12	The convergence of sustainability initiatives with the 3D revolution in online apparel retail not only enhances ecological consciousness but also fosters a more responsible and innovative fashion industry	1.96	1.04
13	3D Scanner will increase the sales of e-commerce websites.	1.87	0.96
14	Virtual 3D Avatar (view from various angles, zoom, rotation, spin) will be favoured	1.86	0.96

5.2 Analysis of Variance

An ANOVA (analysis of variance) was employed to explore potential distinctions among demographic variables, including Gender, Age, Occupation, Marital Status, Annual Family Income, and Education, along with their influencing factors.

Table 5 below shows the results of the ANOVA test. It can be concluded that there is a strong correlation between gender, age, and the occupation of the respondents with their influencing factors as all the fourteen variables have p-values below 0.05.

Table 5: ANOVA test for the three demographic variables and their influencing factors						
Statements	Gender		Age		Occupation	
	F	Sig.	F	Sig.	F	Sig.
The 3-D scanner will resolve the size issue.	7.390	**0.000**	5.387	**0.005**	6.749	**0.000**
The virtual dressing room will give complete satisfaction and enhance the online shopping experience.	2.900	**0.014**	4.995	**0.007**	3.679	**0.003**
3-D scanners help you to buy expensive clothes fearlessly.	4.193	**0.001**	5.346	**0.005**	3.430	**0.005**
Return due to ill-fit will be reduced using a 3-D scanner.	9.844	**0.000**	5.850	**0.003**	4.609	**0.000**
3D Scanner would be useful for plus size and lanky persons who don't fit in regular fitting clothes.	3.884	**0.002**	5.918	**0.003**	4.780	**0.000**
Virtual try-on will be delightful for shoppers	3.627	**0.003**	9.564	**0.000**	11.839	**0.000**
I believe that integrating sustainability practices within the 3D revolution of online apparel retail for personalized and precise fit is crucial for environmental preservation.	3.390	**0.005**	13.612	**0.000**	5.401	**0.000**
Virtual 3D Avatar (view from various angles, zoom, rotation,	4.343	**0.001**	3.952	**0.020**	2.964	**0.012**

spin) will be favoured						
The adoption of 3D technology in online apparel retail, focused on personalized and precise fit, should prioritize sustainable materials and production processes.	5.385	**0.000**	6.069	**0.003**	5.116	**0.000**
Body measurements for customization will be accurate	3.171	**0.008**	5.944	**0.003**	5.365	**0.000**
Consumers should actively support online apparel retailers that prioritize sustainability alongside the implementation of 3D technology for personalized and precise fitting	3.421	**0.005**	5.318	**0.005**	5.147	**0.000**
3D Scanner will soon become an important feature of e-commerce websites.	3.390	**0.005**	13.612	**0.000**	5.401	**0.000**
3D Scanner will increase the sales of e-commerce websites.	4.343	**0.001**	3.952	**0.020**	2.964	**0.012**
The convergence of sustainability initiatives with the 3D revolution in online apparel retail not only enhances ecological consciousness but also fosters a more responsible and innovative fashion industry	5.385	**0.000**	6.069	**0.003**	5.116	**0.000**

H_o1: There is no association of demographics and whether a 3D technology-based sizing system will be appealing for increased online shopping
H_i1: There is an association of demographics and whether a 3D technology-based sizing system will be appealing for increased online shopping

Table 6: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.873[a]	0.762	0.749	874.779
a. Predictors: (Constant), Occupation, Gender, Age				

The table 6 provides the *R* and R^2 values. The *R-value* represents the simple correlation and is 0.873 (the "**R**" Column), which indicates a high degree of correlation. The R^2 value (the "**R Square**" column) indicates how much of the total variation in the dependent variable, *[3D technology-based sizing system will be appealing for increased online shopping]* can be explained by the independent variable, *[Gender, Age, and Occupation of the respondents]* In this case, 76.2% can be explained, which is very large.
The next table 7 is the **ANOVA** table, which reports how well the regression equation fits the data (i.e., predicts the dependent variable) and is shown below:

Table 7: ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	16.426	3	5.475	5.695	.001
	Residual	300.931	313	.961		
	Total	317.356	316			
a. Dependent Variable: *3D technology-based sizing system will be appealing for increased online shopping*						
b. Predictors: (Constant), Occupation, Gender, Age						

This table indicates that the regression model predicts the dependent variable significantly well. This indicates the statistical significance of the regression model that was run. Here, p =0.001, which is less than 0.05, and indicates that, overall, the regression model statistically significantly predicts the outcome variable (i.e., it is a good fit for the data).
The **Coefficients** table 8 provides us with the necessary information to predict *3D technology-based sizing system will be appealing for increased online shopping*, as well as determine whether *demographics* contribute statistically significantly to the model (by looking at the "**Sig.**" column). Furthermore, we can use the values in the "**B**" column under the "**Unstandardized Coefficients**" column, as shown below:

Table 8: Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.533	.225		6.808	.000
	Age	.103	.054	.149	1.898	.039
	Gender	.360	.110	.182	3.264	.001
	Occupation	.006	.065	.007	.089	.029
a. Dependent Variable: *3D technology-based sizing system will be appealing for increased online shopping*						

5.3 Exploratory Factor Analysis

Exploratory factor analysis was conducted on the 14 influencing factors to streamline their size and enhance the manageability of group classification. Principal component analysis (PCA) served as the extraction method, while Varimax was chosen as the rotation method. PCA was preferred for its ability to minimize the loss of original information and delve into the dataset's underlying structure. The factor analysis outcomes, along with the Cronbach alpha validity of the identified influencing factors, are detailed in Table 9.

Table 9: Factor analysis result of the selected influencing factors

Statements	Factor 1	Factor 2	Cronbach's Alpha Validity
The 3-D scanner will resolve the size issue.	0.728		0.947
The virtual dressing room will give complete satisfaction and enhance the online shopping experience.	0.785		0.945
3-D scanners help you to buy expensive clothes fearlessly.	0.703		0.946
Return due to ill-fit will be reduced using a 3-D scanner.	0.729		0.947
3D Scanner would be useful for plus size and tall persons who don't fit in regular fitting clothes.	0.774		0.947
Virtual try-on will be delightful for shoppers	0.771		0.946
Virtual 3D Avatar (view from various angles, zoom, rotation, spin) will be favoured	0.912		0.944
Body measurements for customization will be accurate	0.718		0.945
3D Scanner will soon become an important feature of e-commerce websites.	0.952		0.95
3D Scanner will increase the sales of e-commerce websites.	0.912		0.944
I believe that integrating sustainability practices within the 3D revolution of online apparel retail for personalized and precise fit is crucial for environmental preservation.		0.952	0.95
The adoption of 3D technology in online apparel retail, focused on personalized and precise fit, should prioritize sustainable materials and production processes.		0.914	0.944
Consumers should actively support online apparel retailers that prioritize sustainability alongside the implementation of 3D technology for personalized and precise fitting		0.954	0.944
The convergence of sustainability initiatives with the 3D revolution in online apparel retail not only enhances ecological consciousness but also fosters a more responsible and innovative fashion industry		0.914	0.944

Note: Rotation converged in 6 iterations; KMO measure of sampling adequacy: 0.814; Bartlett's test of sphericity: Approximate chi-square 1129.561, degree of freedom (df) 276, significance (sig.) 0.000.

6. Discussion

The 14 factors influencing the effectiveness of 3D technology in enhancing personalized and precise fit experiences in online apparel retail beyond traditional standard sizing practices were broken down into twofactors, with a total explanatory variance of 76.049%, above the 60% threshold for social science research. All parameter statistics were statistically acceptable, demonstrating the robustness of the EFA.

The first factor consisted of statements: A 3D scanner will resolve the size issue, 3D scanners help you to buy expensive clothes fearlessly, Return due to ill-fit will be reduced using a 3D scanner, 3D Scanner would be useful for plus size and lanky persons who don't fit in regular fitting clothes, Body measurements for customization will be accurate, Virtual 3D Avatar (view from various angles, zoom, rotation, spin) will be favoured, Virtual dressing room will give complete satisfaction and enhance the online shopping experience, Virtual try-ons will be delightful for shoppers, 3D Scanner will soon become an important feature of e-commerce websites, 3D Scanner will increase the sale of e-commerce websites. We can term respondents favouring the above statements as "Optimizing Shopping Experience with 3D Technology"

"Embracing 3D scanner technology revolutionizes shopping experiences. By resolving size concerns, users can confidently invest in expensive garments, reducing returns due to ill-fit. Plus-size and lanky individuals benefit from accurate body measurements, while virtual avatars and dressing rooms enhance online shopping satisfaction. Virtual try-ons delight shoppers, making 3D scanners essential for e-commerce platforms, ultimately boosting sales. Respondents championing these advancements support 'Optimizing Shopping Experience with 3D Technology,' foreseeing a transformative shift in online retail."

The second factor consisted of statements: I believe that integrating sustainability practices within the 3D revolution of online apparel retail for personalized and precise fit is crucial for environmental preservation,

The adoption of 3D technology in online apparel retail, focused on personalized and precise fit, should prioritize sustainable materials and production processes, Consumers should actively support online apparel retailers that prioritize sustainability alongside the implementation of 3D technology for personalized and precise fitting and the convergence of sustainability initiatives with the 3D revolution in online apparel retail not only enhances ecological consciousness but also fosters a more responsible and innovative fashion industry. We can term respondents favouring the above statements as, "Promoting Sustainability in Online Apparel Retail"

Advocating sustainability in online apparel retail is paramount, as echoed by respondents emphasizes the importance of integrating sustainability practices into the 3D revolution of online apparel retail for personalized and precise fits. Prioritizing sustainable materials and production processes in adopting 3D technology is crucial, with consumers encouraged to support eco-conscious retailers. This convergence not only enhances environmental awareness but also cultivates a more responsible and innovative fashion industry, marking a pivotal step in 'Promoting Sustainability in Online Apparel Retail

Consumer perceptions and preferences regarding the adoption of 3D technology for personalized fit solutions in the online apparel retail sector are overwhelmingly positive. Research indicates that shoppers appreciate the ability to visualize how clothing will fit before making a purchase, leading to increased confidence and reduced uncertainty. Moreover, the convenience and efficiency of virtual try-on experiences offered by 3D technology resonate with modern consumers who value convenience and seamless shopping experiences.

The potential influence of 3D technology extends beyond individual consumer experiences to encompass broader implications for online retailers. By enhancing shopper satisfaction and reducing the likelihood of returns, 3D scanners can drive significant increases in sales and establish themselves as pivotal components of the online retail landscape. Retailers that invest in 3D technology stand to gain a competitive edge by offering superior fit experiences that resonate with today's discerning consumers.

In addition to its commercial benefits, the integration of 3D technology for personalized fit experiences in online apparel retail also carries sustainability implications. Compared to traditional sizing methods, which often result in excess inventory and textile waste due to inaccurate sizing, 3D technology offers a more sustainable approach to apparel production. By minimizing the need for mass production and reducing the incidence of returns, 3D scanners contribute to a more efficient and environmentally conscious retail ecosystem.

Consumer consciousness regarding sustainability further amplifies the appeal of 3D technology in online apparel retail. Today's consumers are increasingly mindful of the environmental impact of their purchasing decisions and gravitate towards brands and retailers that prioritize sustainability initiatives. By adopting 3D technology, retailers can align themselves with consumer values and demonstrate a commitment to sustainable practices, further enhancing their brand reputation and customer loyalty.

In conclusion, the effectiveness of 3D technology in enhancing personalized and precise fit experiences in online apparel retail represents a significant advancement in the industry. From facilitating confident purchases of expensive clothing to reducing returns and enhancing sustainability, 3D scanners have the potential to revolutionize the way consumers shop for clothing online. As consumer preferences continue to evolve, retailers that embrace 3D technology stand to reap the rewards of increased shopper satisfaction, sales growth, and a more sustainable future for the industry.

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