

# Online VR store as a sustainable fashion retail space

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## Abstract

**Purpose** – The study applied the information system success model (ISSM) to investigate the influence of information system qualities (ISQs) on consumer responses related to sustainable fashion consumption in the context of comparing 3D VR store and 2D website.

**Design/methodology/approach** – This study designed a questionnaire to measure five ISQs (usefulness, diversity, functionality, reliability and tangibility), immersion in messages and purchase intention. 270 data from women consumers of online fashion stores were collected using Macromill Embrain. Structural equation modeling with Amos 21 and process macro model 7 with SPSS 26 were used for analysis.

**Findings** – This study suggested the relevance of usefulness, diversity, reliability and tangibility among ISQs in evoking immersion in sustainable fashion messages and stimulating the purchase intention. In the moderation of website technology types, the effects of usefulness and tangibility on the immersion in sustainable fashion messages were stronger in 3D VR than 2D condition.

**Originality/value** – The study is meaningful as an initial study that identified the ISQs of online fashion stores by dividing the type of technology into 3D VR and 2D. We offer insights about the relevance and applicability of immersive VR technology in promoting sustainable fashion consumption and show the potential of online VR store as a new kind of sustainable fashion retail space.

**Keywords** Sustainable retail space, VR fashion store, Information system quality, Immersion, Sustainable fashion, Comparison of 2D and 3D

**Paper type** Research paper

## 1. Introduction

Virtual reality (VR) technology has garnered attention not only for its practical and recreational uses, but also for its potential to contribute to eco-friendly initiatives. Certain industries have demonstrated that VR can facilitate environmental sustainability. For instance, the packaging industry has leveraged virtual technology to provide consumers with an immersive experience of the packaging cycle, leading to increased consumer engagement in material conservation. Consumers who saw the brand's message through virtual experience agreed that packaging should be minimized and took steps to recycle and reuse packaging materials (Sakhuja, 2021). Microsoft also has recommended the use of virtual conferences via VR to enhance employee engagement and reduce environmental pollution, particularly during peak traffic hours.

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The fashion industry, which places great emphasis on sensory stimulation, has actively embraced immersive VR technology. VR stores, which seamlessly transition physical stores into the virtual realm, are gaining popularity. With the widespread use of VR by fashion brands, numerous studies have been conducted on perceived value, consumer behavior, and telepresence in VR stores. However, to date, no research has focused on the environmental sustainability of immersive VR spaces. The potential for eco-friendliness in VR stores has been recognized, as they offer the realistic store environment without using actual resources required to build brick-and-mortar stores (Todeschini *et al.*, 2017). This presents an opportunity for companies to give consumers a message about sustainable consumption by providing a VR experience that imparts educational effects and information. Therefore, utilizing VR in the realm of fashion shopping, where sensory experience is paramount, can be an effective communication tool for promoting sustainable fashion consumption.

This research uses the information system success model (ISSM), which outlines the performance of e-commerce, as a framework to investigate the influence of immersion and communication on the VR store experience. An online VR store can be regarded as an information system (IS), given that it is a networking system that generates and distributes content (Nguyen *et al.*, 2023). This study aims to explore strategies for enhancing sustainable fashion purchase in online VR stores that are recognized for their eco-friendly potential. To achieve this, classifying the technology of online shopping websites into two types: 2D and 3D VR, we investigate how ISQ affect the immersion in shopping messages differently depending on the website technology types. Through the comparative experiment of 3D VR store and traditional catalog-type 2D, this study is to show empirical evidence for the new sustainable retail spaces that the fashion industry can offer. This study also endeavors to contribute to the continuous development and changing research trends in IS by investigating ISQ in the context of virtual commerce, in addition to the existing e-commerce trends.

## 2. Literature review

### 2.1 Virtual reality store and environmental sustainability

VR is a technology that utilizes computing media to create an environment that gives users a sense of being present within it (Xue *et al.*, 2020). Online VR stores are being recognized for their potential to promote eco-friendliness as they can provide a store experience similar to physical stores without consuming physical resources (Todeschini *et al.*, 2017). The fashion industry, known for using excessive lighting and display equipment to create a rich in-store shopping experience, has unavoidable environmental costs. Gucci suggested that VR could be used as a way for the fashion industry to respond to the sustainability agenda. Todeschini *et al.* (2017) suggested that inventory-free retailing could be possible in the apparel industry by combining 3D VR functions into a fashion platform. In addition, online VR stores become an eco-friendly retail space for both businesses and consumers as they can reduce the carbon footprint generated by consumers moving to visit physical stores.

VR technology can lead to sustainable consumer behavior not only from a cognitive perspective but also by providing consumers with immersive educational, aesthetic, and entertainment experiences in shopping situations (Sina and Wu, 2019). The experiential value perceived by consumers is known to translate into active engagement in creative or enjoyable activities (Dogra *et al.*, 2023). Therefore, fashion brands can communicate initiatives for the sustainability of stores by inducing natural immersion among consumers through VR technology, thereby increasing consumer cooperation and satisfaction (Gil-Saura *et al.*, 2023). Since online stores are not limited to physical conditions, virtual stores are also more advantageous in emphasizing specific product information, such as eco-friendly labels at the point of sale (Feuß *et al.*, 2022). In this study, we aim to explore the impact of information

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communication on sustainable fashion and the intention to purchase eco-friendly fashion products by focusing on online VR fashion stores, which are considered eco-friendly retail spaces.

## 2.2 Information system success model (ISSM)

[DeLone and McLean \(2003\)](#) defined an IS as “an organized combination of people, hardware, software, communication networks, and data resources that collects, transforms, and disseminates information in an organization”, and proposed the ISSM that is a framework evaluating and analyzing IS performance. The ISSM assumes that an individual’s belief in the information system qualities (ISQ) precedes an attitude and subsequent behavior intention. Prior studies have investigated various performance variables, including content factors such as information quality (INFQ) and technical factors such as system quality (SYSQ), to assess ISQ. Service quality (SERQ) accounts for the growth of e-commerce and the development technology.

**2.2.1 Information quality (INFQ).** The concept of INFQ refers to the content dimension of an IS, measuring the usefulness, accuracy, relevance, diversity, and other attributes of information ([DeLone and McLean, 2003](#)). In online stores, information encompasses all the content produced by the web and the fundamental role of an online store is to provide appropriate information about products and services ([Bobalca et al., 2021](#)). Usefulness refers to the extent to which the content provided by an IS is believed to be helpful and useful to the user’s tasks and diversity pertains to the abundance of information in terms of quality and quantity ([DeLone and McLean, 2003](#)). [Song et al. \(2013\)](#) has revealed that usefulness is the most salient attribute of fashion information on websites. Given that offering diverse information on fashion-related IS can enhance the users’ shopping experience ([Sá et al., 2022](#)), we focused on the factors of INFQ, specifically usefulness and diversity. [Tseng et al. \(2022\)](#) demonstrated mobile shopping that maximize INFQ facilitate consumers’ product comparisons and enhance immersion in the shopping experience. [An et al. \(2021\)](#) showed INFQ in VR content increases immersion and telepresence, leading to increased intention to visit websites. [Shin \(2019\)](#) argued that depth and breadth of information are two components of immersion, and revealed VR environments enable users to immerse themselves in content through depth and breadth of information. [Roh and Son \(2004\)](#) demonstrated that low level of information communication in the medium impairs the level of immersive experience. Therefore, we hypothesized there is a positive correlation between the INFQ of online fashion stores and consumers’ immersion in messages encouraging participation in sustainable consumption.

**2.2.2 System quality (SYSQ).** SYSQ is a critical evaluation factor of IS performance associated with its technical level, measuring the extent to which the system is easily usable, available, responsive, and timely ([DeLone and McLean, 2003](#)). Given consumers’ demand for easy-to-use and easy-to-navigate shopping websites, measuring system functionality through SYSQ is crucial ([Bobalca et al., 2021](#)). [Zhang et al. \(2022\)](#) demonstrated that SYSQ of IS enhances user experience, increases immersion in the provided content, and results in positive evaluations. [Wu et al. \(2022\)](#) mentioned that functionality and usability of 3D VR systems as a sales tool are critical factors in users’ shopping experience. [Xue et al. \(2020\)](#) highlighted functionality and ease of use in virtual commerce environments are important factors that affect immersion in virtual retail stores and are linked to consumers’ desires and positive product recognition. Moreover, when the accessibility and ease of operation of the media are low, the user’s immersive experience can be impaired ([Roh and Son, 2004](#)). Therefore, there would be a positive correlation between the SYSQ of online fashion stores and consumers’ immersion in messages encouraging participation in sustainable consumption.

*2.2.3 Service quality (SERQ).* Due to the advancement of computing technology, IS is now capable of simultaneously performing the roles of both information provider and service provider. SERQ measures the tangibility, reliability, and empathy of IS, and are particularly important in internet shopping where face-to-face communication is absent (Tseng *et al.*, 2022). Website reliability has traditionally been perceived as the most important dimension in online shopping situations (Bobalca *et al.*, 2021) and has been identified as a key factor influencing consumers' adoption of virtual stores (Xue *et al.*, 2020). Visual superiority and the use of up-to-date software on websites give a positive effect on consumer behavior (Gadalla *et al.*, 2013). In the context of virtual stores, interface and appearance have a significant impact on consumers' attitudes towards virtual store usage (Wu *et al.*, 2015). Therefore, in this study, we focused on the tangibility and reliability factors of SERQ in the context of a 3D virtual fashion store. The concept of reliability refers to the degree to which individuals feel that their personal information is secure and rely on the IS providers. Tangibility is an external cue for evaluating IS services that encompasses physical appearance, layout, state-of-the-art equipment and software, and support resources (DeLone and McLean, 2003). Mobile shopping with high SERQ is more likely to be frequently used by consumers, and can effectively assist consumers at each stage of the purchasing process (Tseng *et al.*, 2022). It has been revealed that the higher the perceived trust in service providers, the greater the level of immersion in the service (Kumar, 2022). External factors such as the products display and interior in physical stores, as well as the latest software and equipment used in VR stores, can have a positive effect on consumer immersion and lead to a positive attitude toward the store (Peukert *et al.*, 2019; Pantano and Laria, 2012). Therefore, there would be a positive correlation between the SERQ of online fashion stores and consumers' immersion in messages encouraging participation in sustainable consumption.

### *2.3 Sustainable fashion message (SFM)*

Sustainable fashion products are designed to minimize environmental damage across the entire product life cycle. Commonly referred to as "eco-friendly fashion," "eco fashion," or "green fashion," this emerging trend has gained significant attention in the fashion industry. Numerous fashion brands are actively pursuing environmentally sustainable practices and are communicating their activities and objectives to consumers using various channels. Corporate social responsibility (CSR) initiatives such as sustainability efforts can add value to a business, but the degree to which such value is perceived by consumers depends on how the corporate message is communicated (Grimmer and Woolley, 2014). Therefore, companies and brands carefully approach the adoption of communication strategies.

New technologies can help to activate consumer behavior by providing information that encourages consumer participation. As such, companies can introduce new interactive stimuli in the shopping environment to show their messages and encourage consumer participation (Grewal *et al.*, 2017). For example, consumers are more effectively immersed in hybridized virtual reality through digital screens such as smartphones, computer screens, and holograms (Scholz and Smith, 2016). Regarding the role of spatial factors that can activate consumer immersion, the Harvard research team proposed the psychological well-being and mental activation that users can obtain when exposed to biophilic atmospheres such as green design in online spaces (Biofilico, 2023). In addition, it suggested the need for follow-up research that considers the potential of an online VR integrating biophilic design. This reinforces the necessity of our study that explores the use of online VR fashion store services with environmentally friendly elements. Therefore, we aim to investigate the effect of communicating SFM that encourages sustainable consumption behavior in fashion shopping, specifically in an online technological environment.

### 2.4 Comparison of 3D VR and 2D

Research comparing the effects of VR and traditional 2D content is currently being conducted with a focus on the various attributes of the medium and technology. [Xue et al. \(2020\)](#) found that interactions during shopping in a virtual environment led to more critical evaluation of product information, inducing consumers to engage in more active cognitive activities. In comparison to 2D environments, 3D environments provide a more dynamic interface, rich with informational cues and visually impressive experiences, leading to higher levels of immersion ([Sina and Wu, 2019](#)). In the context of brand messaging, comparing the effects of message communication through 3D VR experiences and 2D videos, [Kim and Song \(2019\)](#) found that the psychological distance between customers and messages decreased and message processing abilities improved in 3D VR experiences, resulting in a more positive attitude towards the brand. Additionally, a study comparing the advertising effects of VR and standard 2D videos showed significant differences between the two types of video ([De Regt et al., 2021](#)). In this study, we aim to compare the effectiveness of information messages communicated through 3D VR stores and regular 2D web stores in the context of online fashion shopping.

Brand VR, which aims to provide customer-centric experiences, can induce customer immersion through various configurations of VR system, such as devices or content that produce VR experiences. However, immersion is an individual consciousness and a context-dependent state, so even consumers exposed to the same brand message through VR can experience varying levels of immersion and exhibit different purchase intention (PI) accordingly ([De Regt et al., 2021](#)). [Roh and Son \(2004\)](#) pointed out that the level of immersive experience can differ depending on various factors such as the amount of information, ease of manipulation, accessibility, immediate feedback and compatibility of an IS. [Xue et al. \(2020\)](#) argued that consumer PI may vary depending on the retail environment in online and virtual commerce, and proposed conditions for an effective virtual commerce environment. Therefore, we hypothesized that even with the same fashion products and SFM, consumer immersion levels and PI may differ depending on the ISQ of 3D VR and 2D websites.

- H1. Online fashion store's ISQ [a) usefulness, b) diversity, c) functionality, d) reliability, e) tangibility] increases the immersion in SFM.
- H2. The immersion in SFM increases PI for sustainable fashion products.
- H3. The effect of ISQ on the immersion in SFM is higher in 3D VR stores than in 2D.

## 3. Methodology

### 3.1 Stimuli and questionnaire development

To exclude the influence of prior attitudes toward existing fashion brands, a new online fashion store was created: one online VR store and one 2D web store. These two stores deal with sustainable fashion products of the same contents (e.g. items, information, messages, mood, etc.). The VR store allows for a full 360° exploration, displaying products like offline stores. When clicking on a particular point in the VR store, four SFMs appear. In contrast, the 2D shopping website displays the same four SFMs on the main page of the homepage and presents the fashion products in an existing online catalog format (see [Appendix 1](#)). When adopting a within-subjects design, order effects where previous stimuli can influence the experience of subsequent stimuli, can occur. In this experiment, we adopted a between-subjects design because we wanted to first examine the main effect of each stimulus on consumers, excluding other situations between 3D and 2D stimuli. Participants either experienced a 3D VR store or a 2D website randomly for at least 4 min. Then, they responded to the questionnaire to measure the variables, which was developed by reviewing prior

studies. All questions were measured on a 7-point Likert scale, and at the end, demographic items such as age, marital status, occupation, education, monthly income and monthly fashion product consumption were collected.

### 3.2 Data collection

This study recruited female consumers in their 20s and 30s, who are regarded as the main focus of fashion brands and familiar to technology. Women in this age group tend to access online shopping sites more frequently and search for more fashion-related information, compared to other age groups (Finances online, 2023). In addition, perceptions of the retail environment may vary based on gender, and this divergence could lead to differences in behavioral responses (Borges *et al.*, 2013), so to control for the additional influence of gender, participants in this study were exclusively limited to females. Since the survey will be conducted based on two different groups (3D VR/2D), we used a 2-sample *t*-test of the G\*Power program to calculate the number of target participants. At a significance level of 0.05 and an effect size of 0.8, the number of samples required to maintain a power of 0.9 is at least 105 per group and at least 210 in total. A total of 300 female consumers participated in an online survey recruited by Macromill Embrain, which is a large research firm in South Korea. The final 270 responses (VR = 138, 2D = 132) were used for analysis, excluding the responses that were those dropped from the manipulation check and because of insincere responses. Appendix 2 depicts the demographic profile of 270 respondents.

## 4. Results

### 4.1 Reliability and validity tests

We conducted the same test for the past purchase of sustainable fashion products, considering that past purchases are crucial to the attitude and future PI (Burlison and Oe, 2018). There was no significant difference in the experience of purchasing sustainable fashion products between the two groups ( $\chi^2 = 0.827$ ;  $p = 0.363$ ). Table 1 demonstrates the validity and reliability of the variables. Factor loadings of each item in ISQ variables, immersion in SFM and PI were higher than 0.6, and the eigenvalue of all factors was 1 or more, so we confirmed that each variable was a single factor. The reliability of each variable was determined by Cronbach's  $\alpha$  and was found to fall over 0.7, surpassing adequate levels. We also verified all average variances extracted (AVEs) were over 0.5 and greater than the squared correlation between the target variable and every other variable, defining the convergent and discriminant validity of the conceptual model. In general, our variables show good measurement properties.

### 4.2 Structural model testing

All the hypotheses in the analytical model were examined through the structural equation modeling (SEM) using Amos 21. Overall, our analytical model shown in Figure 1 represents a good fit to the data set, so we could conclude the proposed model is appropriate for statistical analysis with the data set. The regression weights and the standardized weights of main factors are represented in Table 2. Usefulness and diversity, INFQ of online fashion stores, had positive effects on immersion in SFM at  $p < 0.05$  level ( $\beta = 0.302$ ,  $p = 0.000$ ;  $\beta = 0.084$ ,  $p = 0.038$ ). Reliability and tangibility, SERQ of online fashion stores, were also positively significant for immersion in SFM ( $\beta = 0.164$ ,  $p = 0.016$ ;  $\beta = 0.307$ ,  $p = 0.000$ ) and tangibility had the strongest influence on immersion among the ISQ factors, showing the importance of the attractive appearance in online shopping sites. Functionality didn't show a significant effect on immersion in SFM. These results support H1-a, H1-b, H1-d and H1-e. Immersion in

Construct	Measurement items	Factor loadings	Eigen value	Cronbach's $\alpha$	AVE
Usefulness	<i>Information in the store is ...</i>				
	helping users' shopping	0.807	3.068	0.834	0.564
	necessary to shop	0.807			
	improving shopping efficiency	0.686			
Diversity	<i>Information in the store is ...</i>				
	abundant	0.833	2.791	0.881	0.662
	diverse	0.822			
	sufficiently displayed	0.801			
Functionality	<i>The store system is ...</i>				
	obtained in various ways from each link	0.635			
	convenient to operate	0.885	2.620	0.902	0.757
	convenient to use	0.855			
Reliability	<i>The service provider of the store is ...</i>				
	easy for shopping with proper page layouts	0.810			
	responding to users' requests	0.824	2.584	0.851	0.588
	adequately understanding users' requirements	0.779			
Tangibility	<i>The store is ...</i>				
	stably operated	0.670			
	reliable	0.590			
	showing a look that goes well with the service	0.852	2.320	0.819	0.613
Immersion in SFM	visually appealing	0.810			
	showing the latest tools/software	0.645			
	The contents of SFM are persuasive	0.834	2.973	0.824	0.501
	I feel sincerity of SFM.	0.820			
PI	<i>In this store I would ...</i>				
	I feel sympathy with SFM.	0.786			
	I am going to carry out the contents of SFM.	0.718			
	I focus well on SFM.	0.688			
	<i>In this store I would ...</i>				
	be happy to buy items for my family and friends	0.904	3.949	0.933	0.738
	buy items for myself	0.902			
	purchase items	0.891			
	<i>In this store I would ...</i>				
	recommend purchasing items to people around me	0.887			
	<i>In this store I would ...</i>				
	give priority to purchasing items over other stores	0.859			

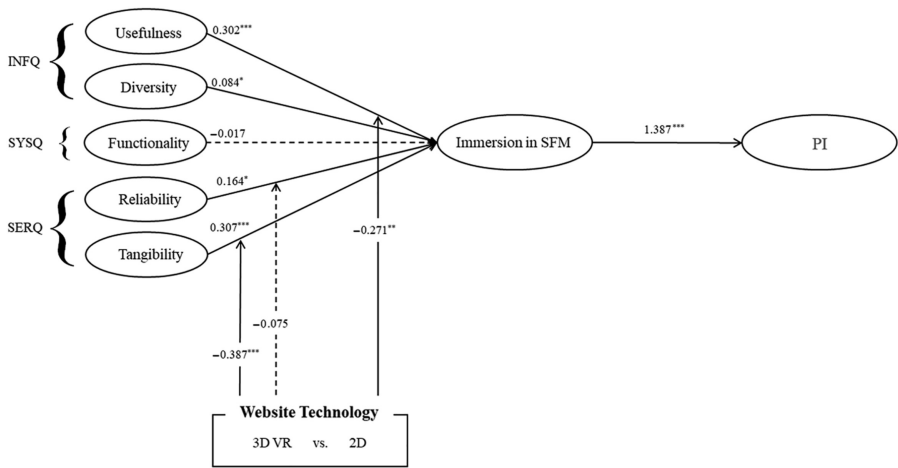
**Note(s):** Usefulness/Diversity – Taylor and Todd (1995) and Palmer (2002), Functionality – Nguyen *et al.* (2023) and Lin (2007), Reliability/Tangibility – Landrum and Prybutok (2004) and Pitt *et al.* (1995), Immersion in SFM – Andrews and Durvasula (1991), PI – Kotler and Keller (2012)

**Source(s):** Table by authors

**Table 1.**  
Results of factor  
analysis

SFM shows a positive and significant relationship with the PI of sustainable fashion products ( $\beta = 1.387, p = 0.000$ ), so H2 was supported.

As the relationships in the analytical model were identified, we tested the mediating roles of immersion in SFM. The bootstrapping method was used with 5,000 samples and the upper



**Figure 1.**  
The result of model analysis

**Note(s):** \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$

**Source(s):** Figure by authors

Hypotheses	B	$\beta$	SE	CR	$p$	
H1a	0.302	0.363	0.059	5.084	0	Supported
H1b	0.084	0.12	0.041	2.077	0.038	Supported
H1c	-0.017	-0.03	0.026	-0.642	0.521	Not supported
H1d	0.164	0.193	0.068	2.409	0.016	Supported
H1e	0.307	0.358	0.06	5.127	0	Supported
H2	1.387	0.913	0.166	8.368	0	Supported

**Note(s):** Model Fit:  $\chi^2 = 678.194$ ; degree of freedom (df) = 330 ( $p = 0.000$ );  $\chi^2/df = 2.055 (< 3.000)$ ; TLI = 0.922 ( $\geq 0.900$ ); CFI = 0.932 ( $\geq 0.900$ ); RMSEA = 0.063 ( $< 0.800$ )

B = Regression weights;  $\beta$  = Standardized regression weights; SE = Standard error; CR = Critical ration

**Source(s):** Table by authors

**Table 2.**  
Structural model results

and lower limit 95% confidence intervals (ULCI; LLCI) were gained for the indirect effect of ISQs on PI via immersion in SFM. The confidence interval for the indirect effect of usefulness (LLCI 0.255; ULCI 0.587) on PI, reliability (LLCI 0.051; ULCI 0.457) on PI, and tangibility (LLCI 0.230; ULCI 0.603) on PI do not include zero. Hence, the mediation of immersion in SFM is statistically significant in usefulness, reliability and tangibility (see Table 3).

#### 4.3 Comparison between 3D VR and 2D

In our model, the website technology (3D VR/2D) acts as a moderator in the relationship between ISQ and a mediator, immersion in SFM. The objective of this study is to explore whether there is any difference in the entire path depending on the website technology. We performed a moderated mediation analysis with 5,000 bootstrap samples using Model 7 of the SPSS PROCESS macro (Preacher and Hayes, 2004), with the independent variables that showed significant effects on the outcome variables in SEM. Table 3 shows that the indirect effects of usefulness and tangibility (X) on PI (Y) via immersion in SFM (M) are positive and increase under the condition of 3D VR ( $\beta = -0.110$ , LLCI -0.202 and ULCI -0.035;  $\beta = -0.144$ ,

Path	B	SE	LLCI	ULCI
Usefulness → Immersion in SFM → PI	0.419	0.086	0.255	0.587
Diversity → Immersion in SFM → PI	0.117	0.062	-0.004	0.252
Functionality → Immersion in SFM → PI	-0.023	0.044	-0.124	0.055
Reliability → Immersion in SFM → PI	0.228	0.103	0.051	0.457
Tangibility → Immersion in SFM → PI	0.426	0.094	0.230	0.603

Path	B	SE	LLCI	ULCI	
X: usefulness	X * W → M	-0.271	0.079	-0.427	-0.116
	X * W → M → Y	-0.11	0.043	-0.202	-0.035
X: reliability	X * W → M	-0.075	0.083	-0.239	0.088
	X * W → M → Y	-0.036	0.041	-0.114	0.045
X: tangibility	X * W → M	-0.387	0.081	-0.546	-0.228
	X * W → M → Y	-0.144	0.045	-0.239	-0.065

**Note(s):** X = Independent variable (usefulness, reliability, tangibility); Y = Dependent variable (PI); M = Mediator (Immersion in SFM); W = Moderator (website technology type: 3D VR = 0; 2D = 1)  
LLCI = lower-limit confidence interval; ULCI = upper-limit confidence interval

**Source(s):** Table by authors

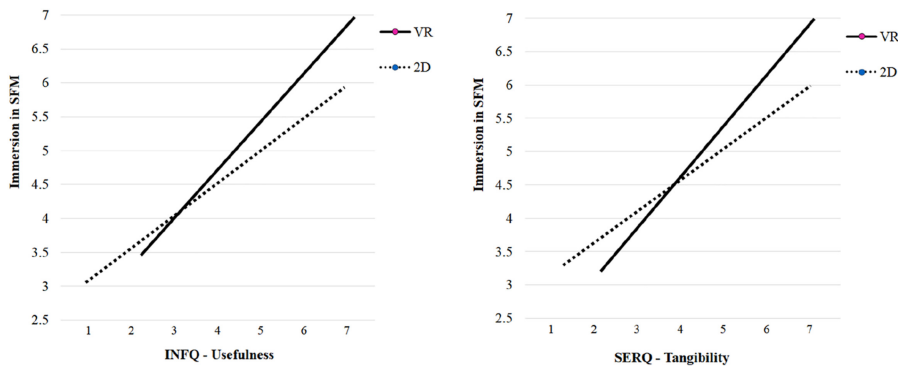
**Table 3.**  
Analysis results of  
mediation path and  
moderated mediation  
effect

LLCI -0.239 and ULCI -0.065). A bias-corrected bootstrap using 5,000 resamples found that the interaction effect of usefulness and website technology on immersion in SFM was significant ( $\beta = -0.271$ ;  $p = 0.000$ ). In addition, the interaction of tangibility and website technology showed the most significant effect on immersion in SFM ( $\beta = -0.387$ ;  $p = 0.000$ ). As shown in Figure 2, the higher the perceived usefulness and tangibility, the higher the immersion in SFM, and this effect is amplified in the VR store for usefulness and tangibility. Thus, our results partly support H3.

## 5. Discussion

### 5.1 Theoretical implications

Virtual reality is transforming the retail landscape by providing consumers with a wider range of content and experiences. Despite the adoption of immersive technologies by some leading retailers the majority of online fashion stores still rely on 2D catalog-like websites.



**Source(s):** Figure by authors

**Figure 2.**  
Interaction of  
usefulness, tangibility  
and website  
technology

Given this background, this study examines how website technology types, such as 2D and 3D VR, moderate the impact of ISQ factors of online fashion stores on consumer behavior. In addition, paying attention to the eco-friendly attributes of VR stores, we figured out immersion in SFM and PI of sustainable fashion products as the consumer behavioral variables. Therefore, our research is meaningful as an initial study that identified ISQ factors of online fashion stores, especially 3D VR websites, and confirmed their influence on consumer behavior related to sustainable consumption.

We investigated the influence of five sub-dimensions of online fashion stores' ISQ on immersion in SFM and found information usefulness and service tangibility hold the most substantial influence. This result is consistent with previous research, which indicated information usefulness as a critical dimension in online shopping sites (DeLone and McLean, 2003; Bobalca *et al.*, 2021). Our finding also aligns with prior studies that emphasized the important role of attractive appearance, physical facilities, and service equipment in both fashion stores and VR stores (Haug and Münster, 2015; Sina and Wu, 2019). However, among the five dimensions of ISQ, only system functionality did not show statistically significant results. This could be attributed to the fact that the stimuli provided to the participants were not actual websites of a real fashion brand, thus limiting their perception about the store system and blurring measurement of system quality impact.

Analyzing moderated mediation effects, we observed that the impact of usefulness and tangibility on behavioral intention, mediated through SFM, was significantly amplified within the VR store environment when compared to 2D websites. This result can be attributed to the fact that the immersive and realistic 360° shopping experience facilitates effective information search and leverages the visual attractiveness typically associated with fashion shopping malls. It is also consistent with Gadalla *et al.* (2013) that explained the visual excellence of websites and the usability of the latest software play an important role in consumer behavior in online shopping. Our findings complement previous research that has highlighted the potential of virtual technologies to enhance consumers' immersion in the retail environment (De Regt *et al.*, 2021; Kim and Song, 2019). Overall, this study contributes to the growing body of research on the potential of online VR stores as effective retail spaces.

Based on the amplified immersion effects of SFM in a 3D VR store, we can suggest the potential of VR stores as sustainable fashion retail spaces in terms of message learning. Consumers might actively engage in learning information through a self-directed experiential approach in VR and Huang *et al.* (2016) has confirmed that consumer participatory experiences lead to a higher immersion in the context of e-commerce. Previous experiment has shown individuals typically remember only 10% of the information they read, whereas when actively engaging in virtual simulations, they can recall up to 90% of the information presented (Lee, 2016). Additionally, the immersive nature of VR content resulted in a concentration and memory recall that surpassed traditional methods of content communication by more than 2.7 times (Lee, 2019). Unlike 2D websites, VR enhances memory retention for brand messages and promotes active information processing, triggering proactive thinking and PI in consumers by incorporating additional meaning or mood within the virtual experience. Considering the ability to effectively communicate information by improving consumer interest and immersion through vivid eco-friendly experiences, high-quality VR fashion stores demonstrate significant potential as new sustainable retail spaces. Therefore, this study holds significance as an initial investigation that empirically proved the effect of a VR-based communication strategy and demonstrated a new sustainable fashion retail space by changing the green branding paradigm.

Finally, in this study, 3D VR stores and 2D websites were created based on the identical content such as items, information, messages, and mood, and a between-subjects experiment was designed. The participants experienced a shopping that was akin to real life by exploring a 3D VR store or a 2D website on their own, after which the variables were measured.

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Therefore, our research is methodologically differentiated from the prior studies that have compared 2D and 3D contents by using limited tools of existing brands or participants' recall of experiences.

### 5.2 Practical implications

The findings of this study emphasize the importance of the ISQ factors in the online fashion retail environment as they can significantly influence brand communication strategies for fashion brands and retailers. The dimensions of information usefulness and service tangibility have the most significant impact on consumer behavior. Thus, brands and retailers need to prioritize providing useful product and brand information and attractive service environment to enhance the online shopping experience, ultimately driving consumer purchase. Our study reveals that VR stores can serve as an environmentally sustainable retail space within the fashion industry, contributing to resource conservation and a reduced carbon footprint (Todeschini *et al.*, 2017). In light of this, it is posited that the effectiveness of VR stores in promoting sustainable fashion can be further enhanced by improving the level of ISQ in virtual retail environments. To this end, immersive experiences need to be facilitated through useful information and visually appealing characteristics, which can be improved through the use of state-of-the-art software in websites.

The pursuit of environmental sustainability through VR technology can also manifest in consumer satisfaction and well-being. A Harvard research team explored the benefits of biophilic interiors in virtual environments, finding that users experiencing biophilic virtual spaces showed stress reduction and decreased anxiety levels. Environmentally friendly virtual design elements provided users with psychological calming effects, enhancing concentration on tasks and ultimately improving overall satisfaction and well-being (Biofilico, 2023). Gil-Saura *et al.* (2023) demonstrated that the combination of innovation and sustainability in the retail environment increases consumer satisfaction. Therefore, based on the results of this study, fashion companies can pursue retail strategies that enhance both corporate performance and CSR by efficiently and environmentally friendly executing practical green branding. This not only contributes to the company's success but also enhances consumer satisfaction and quality of life.

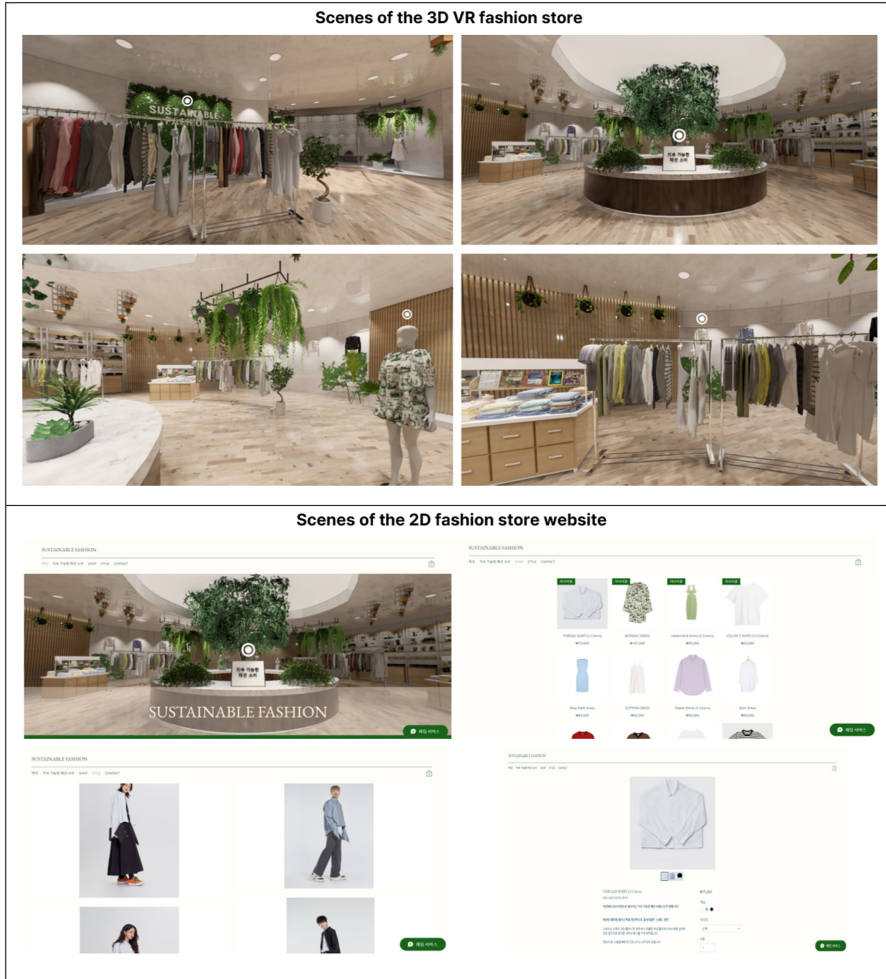
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Variables	Items	Frequency	%
Occupation	Office	148	54.8
	Sales	20	7.4
	Professions	35	13.0
	Management	8	3.0
	Student	20	7.4
	None	39	14.4
The highest level of education	High school	25	9.3
	University	224	82.9
	Graduate school	21	7.8
Monthly income (KRW)	Less than 2,000,000	21	7.8
	2,000,000/-to 4,000,000/-	96	35.6
	4,000,001/-to 6,000,000/-	67	24.8
	6,000,001/-to 8,000,000/-	52	19.2
	More than 8,000,000	34	12.6
Monthly fashion consumption (KRW)	Less than 50,000	34	12.6
	50,000/-to 100,000/-	77	28.5
	100,001/-to 150,000/-	60	22.2
	150,001/-to 200,000/-	47	17.4
	More than 200,000	52	19.3

**Table A1.**  
Demographic profiles

**Note(s):** Samples = 270  
KRW=Korean Won; \$US1 = KRW1,300.40 (as on December 22, 2023)

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