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# Personalizing 3D virtual fashion stores: an action research approach to modularity development



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## Abstract

**Purpose** – The authors conducted an action research study with the aim of understanding current commercial offerings in modular designs in virtual environments and to explore modularity development based on consumer input for the purpose of personalizing three-dimensional (3D) virtual fashion stores.

**Design/methodology/approach** – Through five phases of diagnosing, action planning, action taking, evaluating and specifying learning, the authors attempted to diagnose the current commercial offerings of modular designs in virtual spaces and to identify the right type and the number of modules and modular options for personalizing 3D virtual stores based on consumers' actual designs and focus group input. The authors then further conceptualized modules to serve as an example for developing modularity in 3D virtual reality (VR) stores.

**Findings** – In the diagnosing phase, the authors investigated the modularity structure of cocreating a retail store in two popular virtual worlds: Second Life and The Sims 4. In the evaluation phase, the authors identified modules and modular options for personalizing 3D virtual stores based on a content analysis of consumers' post-design focus group discussions. In the last phase (specifying learning), the authors conceptualized a total of nine modules and 38 modular options for personalizing 3D virtual stores, including style, price point, product category, color, presence of avatar, virtual product try-on, music, product recommendation and product customization.

**Originality/value** – The significance of this study lies in the pioneering methodological work of identifying, creating and visualizing 3D VR modular store options based on consumer input and in improving the authors' understanding of current commercial offerings. This study also enriches design theories on cocreation systems. The authors' suggested modules for personalizing 3D virtual stores could inspire future evidence-based designs to be readily used by VR retailers as well extend the application of mass customization theory from the realm of product development to retail environments.

**Keywords** Modularity, Personalization, Virtual reality, Fashion stores

**Paper type** Research paper

## 1. Introduction

Though virtual reality (VR) shopping is still in its infancy, the retail industry is expected to have approximately 32 m VR and augmented reality (AR) users by 2025 (Goldman Sachs, 2016). A

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report from Goldman Sachs (2016, p. 4) suggests that "VR/AR has the potential to spawn a multibillion-dollar industry, and possibly be as game-changing as the advent of the PC." After Jaron Lanier coined the term "virtual reality" in 1989 (Krueger, 1991), various scholars debated the definition of VR (see Steuer, 1992; Krueger, 1991). Though many scholars first tied the definition of VR to a particular hardware system, i.e. "googles 'n' gloves," as noted by Steuer (1992), most studies adopted a broader definition of VR as a simulated environment in which we experience telepresence, i.e. a sense of presence in a space other than the one we are in (Biocca, 2015; Steuer, 1992). VR that relies on googles or integrates body movements with the simulated environment is generally referred to as a form of immersive environment, while the 360° representations of three-dimensional (3D) environments accessed on a flat screen, such as Second Life, World of Warcraft and other social spaces and games, are referred to as nonimmersive VR (Steed and Schroeder, 2015). Nevertheless, 3D VR environments are characterized by sensory-rich and 3D spaces, often with vivid navigation interfaces and customizable avatars that can help consumers experience products and establish virtual social identities, as well as the potential for providing real-time communication and interaction among users (Caboni and Hagberg, 2019; Moon *et al.*, 2013; Nah *et al.*, 2011).

Previous research on 3D VR/AR environments has investigated their influence on a variety of consumer emotional, cognitive and behavioral variables (see Table 1), such as enjoyment, affect, playfulness, retail interest or pleasure, decision comfort, sense of telepresence, sense of presence or social presence, flow experiences, self-efficacy, hedonic or utilitarian values, attitudes, word-of-mouth intentions, engagement, trust, satisfaction, willingness to invest time, purchase intention, time spent, money spent, purchase rate, brand recall and brand equity (see Baker *et al.*, 2019; Bressoud, 2013; Faiola *et al.*, 2013; Huang and Liao, 2017; Jin, 2009; Jin *et al.*, 2017; Liu, 2010; Liu and Uang, 2016; Luse *et al.*, 2013; Martínez-Navarro *et al.*, 2019; Nah *et al.*, 2011; Papagiannidis *et al.*, 2013; Wu *et al.*, 2013; Yim *et al.*, 2017). The effectiveness of generating favorable consumer responses in 3D, two-dimensional (2D) virtual and physical store environments has also been compared from different angles. Though findings are mixed, 3D environments have been found to outperform 2D and physical environments in many important areas, such as the individual's understanding of information, sense of telepresence, enjoyment, brand recall, brand equity, time spent on shopping and purchase and other behavioral intentions (Baker *et al.*, 2019; Martínez-Navarro *et al.*, 2019; Bressoud, 2013; Van der Land *et al.*, 2013; Nah *et al.*, 2011).

A variety of businesses have experimented with VR/AR offerings. For instance, China's e-commerce giant Alibaba launched its VR shopping platform "Buy+" during its Singles' Day sales event (similar to Black Friday) on November 11 in 2016 and an AR game similar to PokémonGO in 2017 to bond with their customers as well as to keep retail brands in their ecosystem (PYMNTS, 2017; Rick, 2017). Amazon, Zappos, eBay, IKEA, LEGO and Häagen-Dazs have also pioneered VR/AR retailing (Rick, 2017). As seen in these exemplary cases, we are moving toward a 3D Internet (Alpcan *et al.*, 2007). Although notable progress in VR retailing has been made in the industry, innovation derived from research into how VR can offer consumers unique, differentiated shopping value is still limited. Especially in this digitized, interconnected era, consumers' demands for differentiation in unique shopping value are increasing (Popomaronis, 2017). Breakthroughs in sustaining consumers' interest in VR shopping are yet to be seen, though it seems the promises of VR are beginning to be realized (Grewal *et al.*, 2017). Despite the appealing psychological and behavioral outcomes shown in previous research on 3D VR applications in a variety of fields in addition to marketing and retailing, such as medicine (Opris *et al.*, 2012; Powers and Emmelkamp, 2008), architecture (Okeil, 2010), tourism and hospitality (Nayyar *et al.*, 2018), real estate (Pleyers and Poncin, 2020), education (Kozhevnikov *et al.*, 2013) and museum exhibitions (Parker and Saker, 2020), retailers and marketers alike need to innovate when it comes to how 3D VR

| 3D VR/AR features | Response variables | Method (sample) | Key findings |
| --- | --- | --- | --- |
| Online website vs virtual store in Second Life (Baker *et al.*, 2019) | Perceived ease of use<br>Social presence<br>Telepresence<br>Usefulness<br>Trust<br>Enjoyment<br>Attitude | Online shoppers making a purchase in a virtual clothing store in Second life and then a purchase on Land's End's website: within-subject experiment ($n = 237$) | In both online website and Second Life, perceived ease of use and social presence had a positive influence on attitude through perceived usefulness, trust and enjoyment. But only in Second Life, telepresence had a significant influence on attitude through trust and enjoyment |
| Display device<br>Content format (Martínez-Navarro *et al.*, 2019) | Emotion<br>Discomfort<br>Affective appraisal<br>Presence<br>Brand recall<br>Purchase intention | A 3 (display devices: 24" PC monitor, a large-screen powerwall, 6 m wide × 3 m high and an HTC Vive HMD) X 2 (content formats: 360°, 3D) + 1 (control group (CG)) between-subject ($n = 178$) | All VR formats outperform the physical environment in the sense of presence, brand recall and purchase intention. VR influences purchase intention through two routes: one through emotions and sense of presence and the other through affect and brand recall. Discomfort does not influence sense of presence or brand recall |
| Interactivity vividness<br>Novelty (Yim *et al.*, 2017) | Media usefulness<br>Enjoyment<br>Attitude<br>Purchase intention | AR vs web product presentation of sunglasses and watches | AR outperforms web in perception of novelty, immersion, enjoyment, usefulness, positive attitude and purchase intention. Immersion mediates the relationship between interactivity/vividness and usefulness and enjoyment only in the AR condition |
| Interactivity<br>Sociability (Jin *et al.*, 2017) | Social presence<br>intention to purchase | Online survey of World of Warcraft players ($n = 214$) | Sociability and interactivity positively affect social presence and then intention to purchase. User engagement and its antecedents, social ties and social identity are also predictors of intention to purchase |

(*continued*)

**Table 1.** Summary of research on 3D virtual and augmented reality (VR/AR) features

| 3D VR/AR features | Response variables | Method (sample) | Key findings |
|---|---|---|---|
| Self-location<br>Haptic imagery (Huang and Liao, 2017) | Sense of body ownership<br>Ownership control<br>Engagement<br>Flow<br>Concentration<br>Playfulness<br>Time distortion<br>Exploratory behavior<br>Wiliness to invest time<br>Satisfaction | Laboratory experience of virtual fitting using ARIT, followed with a questionnaire ($n$ = 336) | Self-location and haptic imagery positively affect sense of body ownership, ownership control and engagement which serve as mediators for flow experience. Flow experience positively affects concentration, playfulness, time distortion, exploratory behavior, wiliness to invest time and satisfaction |
| 2D vs 3D displays<br>Depth perception cues (Liu and Uang, 2016) | Sense of presence<br>Cybersickness<br>Task performance | 2 (high/low depth perception cues) × 3 (types of display: autostereoscopic, stereoscopic and 2D monocular displays) between-subjects experiment in a simulated 3D virtual store ($n$ = 60; mean age of 65 years) | Autostereoscopic display with high-quality depth perception cues leads to the highest sense of presence. Cybersickness is most evident with low depth perception cues using 3D stereoscopic displays |
| 3D virtual vs real-life supermarkets (Waterlander *et al.*, 2015) | Proportional food expenditures on 18 food groups | Virtual shopping for food compared with real-life shopping results. VR shops were self-downloaded ($n$ = 86) | The biggest significant differences in expenditures between virtual and real supermarkets are dairy, fresh fruit and vegetables and snacks. In real life, participants buy more snacks and fruit and vegetables but less dairy products than in virtual stores |
| Experimental real store vs 3D virtual store (Bressoud, 2013) | Affective, cognitive, conative attitudes, time spent, purchase rate | Participants shopped for a list of five products, including cereals in both virtual and real stores ($n$ = 200/each store) | Affective and cognitive attitudes are higher in real than in virtual stores. Participants spend less time in the real than the virtual store. No significant differences for purchase rate |
| Realism<br>Immersion<br>Interactivity (Van der Land *et al.*, 2013) | Individual understanding<br>Cognitive load<br>Shared understanding<br>Group decision-making | A total of three visual presentations of apartments (2D, 3D and 3D immersive) between-subjects experiment with teams ($n$ = 192 in teams) | 3D VR is more effective than 2D info presentations in individual understanding. Static 3D info presentation is more effective than immersive 3D VR in shared understanding and group decision-making |
| Second Life VR experience (Faiola *et al.*, 2013) | Flow<br>Telepresence | Online survey with Second Life users ($n$ = 115) | Both flow and telepresence are experienced by the users and the two variables are correlated |

**Table 1.**

(*continued*)

| 3D VR/AR features | Response variables | Method (sample) | Key findings |
|---|---|---|---|
| A virtual learning experience in Second Life (Luse *et al.*, 2013) | Acceptance of VR tech<br>Self-efficacy | Before, after-intro and after-use of a virtual experience in Second Life surveys on user acceptance of VR technology and self-efficacy ($n$ = 59 students) | Self-efficacy increases over time, but user acceptance decreases in a highly correlated pattern |
| Control<br>Color vividness<br>Graphics vividness<br>3D authenticity<br>(Papagiannidis *et al.*, 2013) | Hedonic value<br>Utilitarian value<br>Engagement<br>Enjoyment<br>Satisfaction<br>Purchase intention | Graphic resolution modes (medium vs high) in a 3D virtual store: within-subjects experiment ($n$ = 150) | Factors of control, color vividness, graphics vividness and 3D authenticity positively predict simulated experience, which along with hedonic and utilitarian values positively predict engagement, which in turn positively affect enjoyment and satisfaction and then purchase intention |
| A total of three merchandise display methods in 3D virtual stores (Wu *et al.*, 2013) | Retailer interest<br>Retail pleasure<br>Perceived merchandise quality<br>Patronage intention<br>Money spent | A total of three scenario (merchandise grouped based on color, style coordination and visual texture) between-subjects experiment ($n$ = 145) | Subjects shopped in the color store show higher retail pleasure and patronage intention than in the other two. But they spend more virtual money in the style coordination store than in the rest. Retailer interest and retail pleasure moderate the relationship between display methods and patronage intention. Fashion involvement is a moderator between display methods and retailer interest |
| 3D virtual world vs 2D images of the virtual world (Nah *et al.*, 2011) | Telepresence<br>Enjoyment<br>Brand equity<br>Behavioral intention | A virtual hospital tour in Second Life vs 2D screen shots of the 3D tour with equivalent audio info | 3D VR outperforms 2D presentations in terms of telepresence, which in turn affects enjoyment and then brand equity and behavioral intention. However, 3D VR has a negative effect on brand equity, comparatively |
| Social awareness<br>Location awareness<br>Task awareness (Goel *et al.*, 2011) | Cognitive absorption<br>Intention to return to VW | A survey after a directed SL experience ($n$ = 171) | Social, location and task awareness positively influenced cognitive absorption, which in turn positively influenced intention to return to VW |

(*continued*)

**Table 1.**

| 3D VR/AR features | Response variables | Method (sample) | Key findings |
|---|---|---|---|
| Product category dominant grouping Landmark design (Liu, 2010) | Route knowledge Survey knowledge Time spent finding goods | 2 (goods-classification: absence or presence) × 8 (types of landmarks ($n$ = 128; mean age of 70) | With goods-classification landmarks in a 2D image show the best results in spatial cognition in terms of route and survey knowledge and using the shortest time to locate goods |
| Modality richness of advertising (Jin, 2009) | Attitude toward product purchase intention Enjoyment of online shopping | 2 (low vs high product involvement) × 2 (text-visual vs audio-visual modality) between-subjects experiment in Second Life ($n$ = 48 college students) | Modality richness has stronger effect on all response variables for consumers with low product involvement |

**Table 1.**

spaces are configured to attract consumers and provide them with enhanced, differentiated value.

Personalization of an interactive 3D VR shopping environment may provide a promising solution. The use of artificial intelligence (AI) for personalization to benefit retailing is an increasing trend (Shankar, 2018). As an example of personalized 3D VR spaces, Amazon Sumerian, a web-based platform launched in 2017 by Amazon, enables users to customize 3D VR/AR spaces and digital hosts. Virtual worlds, such as Second Life and Sims, also offer a variety of personalization tools for users to cocreate their environments and identities. Advances in digital technology and data mining have also enabled personalized online shopping experiences, such as personalized marketing communications, product recommendations based on browsing or buying behavior and virtual clothing try-on using personalized mannequins or avatars.

The aforementioned VR personalization experiments by retail giants (e.g. Amazon) have not as yet become profitable business-to-consumer (B2C) VR shopping environments. Scholars have proposed design principles for virtual worlds (Chaturvedi *et al.*, 2011), but research is still lacking into how 3D VR retail stores should be set up (Xue *et al.*, 2020), let alone how to add personalization into the mix. Kohler *et al.* (2011, p. 773) point out that “the experience users have with the co-creation system is the key to making virtual places a vibrant source of great connections, creativity, and co-creation.” Codesign, as a key ingredient of personalization, refers to a process of involving end users in the cocreation of a product or an environment based on their individual specifications using a provider’s preconfigured modular options (see Piller *et al.*, 2003). Thus, the aim of our research is to (1) understand current commercial offerings of modular designs in virtual environments; (2) explore how a VR shopping environment might be configured that offers the right type and the number of modules and modular options for the end user to codesign a VR store and (3) experiment in developing modules in 3D VR retail spaces based on empirical findings from our action research study. Thus, our action research is designed to answer the following questions: how is modularity configured for the codesign process in commercial virtual worlds? What features of a 3D VR retail space do consumers truly desire to personalize? And, lastly, based on evidence from data we collected, what types of modular VR store options for codesigning 3D virtual fashion stores can be configured? Our study experimented with personalizable VR module development based on actual consumer input, which may inspire evidence-based VR designs and much needed discussion of the actual needs of individual consumers in VR retail spaces.

## 2. Literature review

### *2.1 Personalization: from product development to product presentation and shopping environment*

The idea of codesigning 3D virtual stores is rooted in research on mass customization (MC). The key appeal of MC is its involvement of end users in codesigning products that better suit individual user's needs or wants (Piller *et al.*, 2004; Pine, 1993). Personalization in product development has been a widely used business strategy for over three decades. A variety of apparel brands have launched product lines for MC, such as Levi's, Land's End, Brooks Brothers, NIKEiD and MIAdidas. Many online start-ups have built their entire business structure on the premise of MC or codesign, such as Cafepress, Zazzle and Threadless. Adopting this MC model, companies only make products to individual orders and thus are able to keep minimal inventory on hand. The consumer benefit of MC is the ability to purchase customized instead of standardized products, as well as the satisfaction and enjoyment of the codesign experience (Fiore *et al.*, 2004; Franke *et al.*, 2010; Wu *et al.*, 2015a, b). Extant research indicates that the perceived uniqueness of a customized product positively influences a consumer's willingness to pay for the product (Franke and Schreier, 2008).

Applying this idea of codesign to the design of 3D VR stores expands the focus of MC from product development to product presentation and shopping environment. However, existing research into personalization in VR shopping is limited to functionality, such as topics relating to spokes-avatar shopping assistance (Corvello *et al.*, 2011; Jin and Bolebruch, 2013) or price search assisting agents (Iyer and Pazgal, 2003), instead of the design or aesthetic of the whole shopping environment.

Similar to personalized products, personalized 3D VR stores can meet individual user's needs and preferences for navigation, functionality (e.g. sociability, interactivity, product search, advertising control, content management), transaction and security levels, product assortment and display and store atmosphere and aesthetic. In real life, virtually no shops or stores are designed *only* for a single individual. But in VR, each user *can* have a unique store with its function and look precisely defined by the individual user. Thus, our research can shed light on configuring a VR shopping environment for individual users to personalize a unique 3D VR store based on their aesthetic, functional and hedonic preferences. Success stories from MC show that retailers' ability to configure such user-friendly, sensible environments is key to attract the continued engagement and consumption of users.

### *2.2 Cocreation and modularity in VR environments*

Though a plethora of research has tested various features of 3D VR environments and their effects on consumer response, the conceptualization of the totality of a cocreated, persuasive 3D VR environment as a selling tool is still lacking. To provide direction on designing cocreation systems for virtual worlds, Kohler *et al.* (2011)'s action research identified four critical experience design components: pragmatic (product-, usage-related information), sociability (as community or group members), usability (human–computer interactions) and hedonic (mental stimulation or entertainment) experiences (see also Nambisan and Nambisan 2008). One key lesson, they stated, was to involve users to cocreate the cocreation system to enhance collaborative experiences. From a design angle, Chaturvedi *et al.* (2011) proposed principles to encourage user cocreation of virtual worlds, including (1) accommodating diverse users as citizens of the virtual world; (2) citizen-centric views of the virtual world; (3)

allowing, sustaining and protecting user-created content; (4) multiple levels of computational experimentation and (5) reconciling real and virtual worlds.

However, experimentation into how modularity should be configured is scarce, despite the key role modularity plays in the success of MC. Modularity in a 3D VR space governs the codesign structure and specifies how aspects of the space (such as navigation, product display, interior décor) can be divided into parallel options that allow users to freely choose and assemble into a holistic environment (see Baldwin and Clark, 1997). Some features of 3D VR environments that were previously tested for their effects on consumers might be suited for modular offerings, such as content formats (360° vs 3D), interactivity, vividness, novelty, realism, sociability, product variety, product grouping methods, price points, store atmosphere, landmark design, modality richness, types of service and support, security and privacy levels and displays of advertising (see Huang and Liao, 2017; Jin, 2009; Jin *et al.*, 2017; Liu, 2010; Martínez-Navarro *et al.*, 2019; Van der Land *et al.*, 2013; Wu *et al.*, 2013; Yim *et al.*, 2017). For example, Wu *et al.* (2015a, b) involved consumers in codesigning visual merchandising in 3D VR stores. From a content analysis of consumer codesigned visual merchandising directives in 3D virtual stores, they described the key domain facets of visual merchandising that are pertinent to a 3D VR selling space as (1) merchandise presentation, including fixturing, product density, manner of presentation and product adjacency; (2) in-store environment, encompassing layout and interior and (3) in-store promotion and signage. Though their main purpose was to guide visual merchandising directives for brick-and-mortar stores, user-generated ideas in fashioning 3D VR store simulations can shed light on the conceptualization of 3D VR stores.

All the aforementioned store environmental features can be designed as modules with preconfigured options to facilitate the cocreation of 3D VR stores. For instance, a module of product density could contain two options of high vs low density. A fixturing module could include options of various combinations of two-, four-way stands, convertibles, tables, roll racks, round racks, gondolas, antique furniture and wall fixtures. An interior color module might offer limited options of color families or unlimited choices from color palettes. A comprehensive understanding of the characteristics of 3D VR selling spaces and consumer's unique needs in VR environments is essential in order to set up the right modularity for 3D VR selling spaces.

## 3. Method

We took a participatory action research approach in a three-year time period in order to understand and develop modularity for 3D VR selling spaces. Reason and Bradbury (2001, p. 1) define action research as "a participatory, democratic process concerned with developing practical knowing. . .it seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people." It is ideally suited to the study of technology in its human context in applied fields such as information systems (Baskerville and Wood-Harper, 1998, cited in Kohler *et al.*, 2011). It is "particularly suited when researchers need to get deeply involved to gain investigative value from an insider's view of a problem context and when the change process itself is the subject being studied (Street and Meister, 2004; cited in Kohler *et al.*, 2011, p.775)." We adopted this approach based on the belief that the design of a personalization system needs the active participation of the users and their collaborative, creative solutions. The users should be the change agents who shape the design of VR personalization platforms that intend to enhance their shopping experience. Thus, modeling after Kohler *et al.*'s (2011) action research approach, our experimental work went through five phases to achieve our research goal: (I) diagnosing; (II) action planning; (III) action taking; (IV) evaluating and (V) specifying learning (Baskerville and Wood-Harper, 1998; Susman, 1983).

These five phases of action research are described as follows:

In the "diagnosing" phase, we content analyzed two popular virtual worlds, Second Life and The Sims 4, to learn about the modularity structure for personalizing a 3D VR space as well as to identify gaps in their offerings if used as 3D VR selling spaces. These two virtual worlds were selected because of their large user base and distinctively different interfaces and options for creating VR stores. Following Lynch and Peer's (2002) suggestion, observable surface-level content was identified as the unit of analysis. To investigate their offerings in creating a personalized virtual store, one researcher registered as a real user and counted all modules and modular options when going through the process of cocreating a virtual store in these two virtual worlds.

In the "action planning" phase, we used six predesigned 3D VR modular stores, including options of high vs low product density; bright vs dim lighting and product adjacency based on outfitting vs color, as a simplified version of a codesign system for users to start personalizing a store for themselves. For example, in the case of product adjacency based on outfitting, apparel products that could be mixed and matched into complete outfits were displayed next to each other; but in the case of product adjacency based on color, apparel products in similar colors in terms of warmness or coolness were displayed next to each other.

The "action taking" phase started with recruiting participants to go through the codesign process. The participants were asked to freely change anything in the store after they selected and picked from these modular options based solely on their individual shopping needs and preferences. So, for example, one research participant might select from these preconfigured options and assemble a store that features a low product density, product grouping based on color, dim lighting and various other personalized features. Also, since our student participants personalized the stores for themselves, the apparel products used in these stores targeted consumers in their late teenage years and early 20s.

In the "evaluation" phase, the research participants formed focus groups and reviewed their individually personalized 3D virtual stores. They then discussed within their groups the most critical and appropriate features of a 3D virtual store for personalization from their perspectives as consumers. The idea of group creativity supports the belief that individuals often produce creative outcomes through collaborative thinking (Paulus and Nijstad, 2019). The transition from an individual codesign activity to group discussions was intentional. Focus groups can help participants reflect on their own work, stimulate creativity and more effectively screen out unachievable ideas. Written reports from focus group discussions were then content analyzed to gain a holistic picture of the optimal modularity configuration.

In the last phase, "specifying learning," the lessons learned were described in both verbal and visual forms, e.g. some are in the form of actual designs of modular stores as personalization examples. We also compared and contrasted our findings with Nambisan and Nambisan's (2008) and Kohler *et al.*'s (2011) theories concerning cocreation in virtual worlds to contribute to building theories.

## 4. Results and discussion

### *4.1 Phase 1: diagnosis of modularity structure in virtual worlds*

The preconfigured codesign system in Second Life for a user to build a store contains four large modules: general module, object module, feature module and texture module. The general module provides 13 options of basic geometric shapes, e.g. cubes, spheres, cylinders, pyramids, etc. The object module defines the position, size, rotation and path cut, etc. of the object. Most of these submodules provide infinite options. The feature option specifies the object's physical shape type, softness, gravity, drag and so on, followed by the texture module, which mostly deals with surface design details, such as colors, transparency, material and textural qualities. Both the feature and texture modules offer a great number or infinite options. There is an additional content module that can be used to drag objects into a user's own inventory if permitted. After finishing one object, users can link the object with other "prims" (a 3D unit for building or modifying objects) to create more complex objects such as a virtual store. Alternately, users can purchase objects from the marketplace to build their stores.

Comparatively, The Sims 4 provides a simpler and a more modularized structure for cocreating a virtual store. After choosing a location to open a virtual store, a user selects building exterior (e.g. roof patterns, roof sculptures, roofs, floor patterns, doors, windows), interior (e.g. wall patterns, floor patterns), furniture (e.g. chairs, tables, mirrors), fixtures (e.g. shelves, racks, counters, register), mannequins, promotional signage and decorative items (e.g. plants, pictures). The Sims 4 provides several types of merchandise in a variety of colors and textures. Therefore, users can present the merchandise in various colors or textures and create product-coordination styles on their own. There are also abundant modular options for creating walls (167 options), doors (72 options), windows (69 options) or floor layouts (90 options), etc.

In sum, both Second Life and The Sims 4 offer a great variety of modules and modular options for cocreating store environmental features, such as exteriors, interiors, merchandise, fixtures and props, lighting and so on. This great variety might seem overwhelming to the user and these environments are not designed for selling real-life products and thus, the built-in modularity lacks effective product presentation strategies, such as product grouping and display methods or pathfinding assistance features.

### *4.2 Phase 2: action planning*

In this phase, we used six predesigned modular stores that encompassed both environmental and product presentation modules as a simplified codesign system and an inspiration for users to cocreate 3D virtual stores. We chose these six modular stores among many that we designed previously based on the idea of experimenting with modular stores precisely because of what we learned from the modularity structure of the two virtual worlds in phase 1: modules provided in virtual worlds for personalization are primarily focused on environmental features of the VR store. Our predesigned modular stores contained two modules, "product density" and "product adjacency" (each had two modular options), that specifically addressed product presentation strategies. However, there was also an environmental "lighting" module that represented the inclusion of environmental features for personalization.

### *4.3 Phase 3: action taking*

In total, 170 undergraduate students in visual merchandising classes at Midwestern University in the USA participated in the codesign process for course credits. All instructions were given in a consistent manner. Within a time period of six weeks, they used MockShop, a 3D virtual retailing software package designed for the fashion industry, to personalize a virtual store. Our participants were encouraged to exert their creative freedom to codesign an ideal store based solely on their own preferences and needs. The six predesign modular stores were presented and given to them as a starting point for the codesign process. Using the preconfigured modular options, our participants were able to customize their personalized 3D VR retail spaces that more appropriately matched their needs. They could pick and base their designs on one module that reflects a unique combination of the six total options of high vs low product density, color vs outfitting product adjacency and bright vs dim lighting. The participants were then asked to think about all other important features of the VR store for personalization.

*4.4 Phase 4: evaluation*

After individually going through personalizing a VR store, the participants formed focus groups of three to four students to first review each individual's personalized 3D VR store and then to discuss which features of their VR stores should be modularized and what modular options should be provided from a consumer's perspective. For example, the price range, music, color theme, product grouping methods, floor plan and fixture style could be suited to provide useful and meaningful variations for users to codesign a VR space. On the other hand, a virtual store's ceiling height or scent might not be as critical or possible in a virtual shopping experience. A total of two researchers independently content analyzed written reports from 46 focus group discussions. The reports were coded in three categories: "pathfinding assistance," "environment" and "manner of product presentation," adopting Ha *et al.*'s (2007) typology of atmospherics. Within these three categories, 17 first-level modules, including navigation, layout, clerk assistance, overall theme, lighting, interior material, color, product assortment, scent, in-store advertisements, music, task area, product organization, use of fixtures, ways of displaying, changing views and virtual try-on, were identified (Wu *et al.*, 2021). There were also a total of 207 modular options suggested in the focus group discussions. Most often, the number of suggested options for any module was 3–9. This phase thus identified the appropriate type and the number of modular options.

*4.5 Phase 5: specifying learning: development of modules and modular options*

Based on consumer ideas for modules and modular options from phase 4, we further conceptualized nine modules, each with two to eight options (see Figure 1). For example, based on the consumer's idea of an "overall theme" module, we developed a "style" module that contains thematic options for the overall style of the VR store, e.g. modern, trendy, classic and European styles. The selection of these nine modules was intentional as they included both functional and aesthetic features and contained modules dealing with manner of product presentation, which is lacking in commercial virtual worlds currently offered for personalization. By no means did we intend to provide an exhaustive list of modules or modular options. The nine modules for personalizing 3D virtual fashion stores included

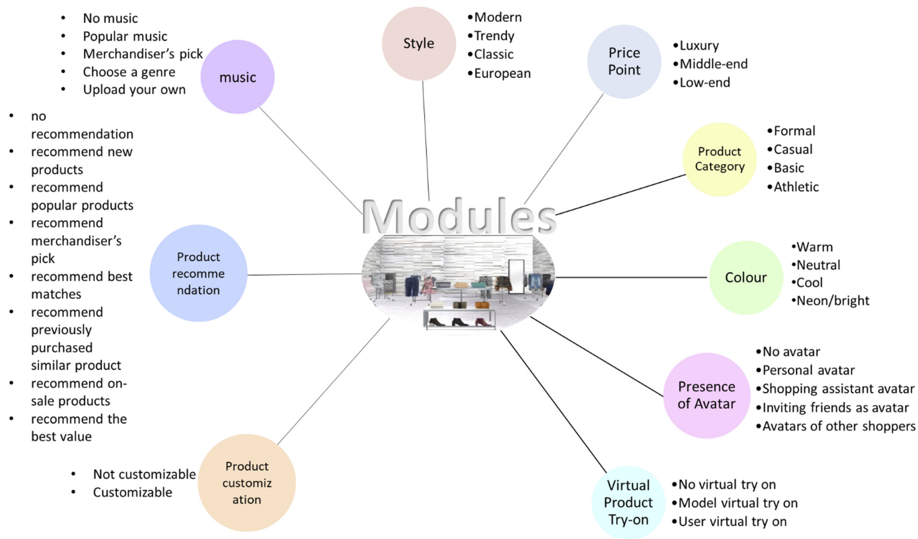


**Figure 1.**
Selected nine modules for personalizing a 3D VR fashion store

"style" (four options: European, classic, modern and trendy; see Figure 1), "product category" (four options: casual, formal, athletic and basic), "colour" (four options: warm, neutral, cool and bright/neon), "price point" (three options: high-end, middle-end and low-end), "the presence of avatar" (five options: no avatar, personal avatar, shopping assistant, inviting friends as avatars and many avatars of other shoppers), "virtual product try-on" (three options: no virtual product try-on, model virtual product try-on and user virtual product try-on), "music" (five options: no music, popular music, merchandiser's pick, choose a genre and upload your own playlists), "product recommendations" (eight options: no recommendation, recommend new products, recommend popular products, recommend merchandiser's pick, recommend best matches, recommend previously purchased similar product, recommend on-sale product and recommend the best value) and "product customization" (two options: not customizable and customizable). Each module contains four options on average with a range from three to eight, totaling 38 options for personalizing 3D virtual stores.

Using MockShop, we brainstormed and created 15 modular store options to serve as an example and an inspiration source for modular store development (see Figure 2 for an example). These modular stores were in the same size, for young women in their 20s, with spring/sall season products and they included garments as well as accessories, such as bags, shoes and hats. There was an average of 40 products in each store. These modular stores were designed collaboratively and intuitively by the researchers and meant to match the verbal descriptors of each option for the mass fashion market.

## 5. Conclusion

This participatory action research was conducted to shed light on configuring a VR shopping environment that offers the right modularity for individual users to personalize a unique 3D VR store based on an understanding of the current commercial personalization offerings in 3D virtual worlds as well as user needs and preferences. Extending personalization from product development to product presentation and retail environments reflects a shifting paradigm in retailing that emphasizes offering a totality of differentiated shopping experiences instead of merely high-quality products. Furthermore, adopting a consumer orientation in store design to incorporate the end user's perspective in the early stage of the design process represents the basic element of successful retailing strategies (Di Blasi and Pantano, 2015). Personal-level differentiation in digital retail environments has quickly become a reality. In contrast to the traditional store design process in which consumers'

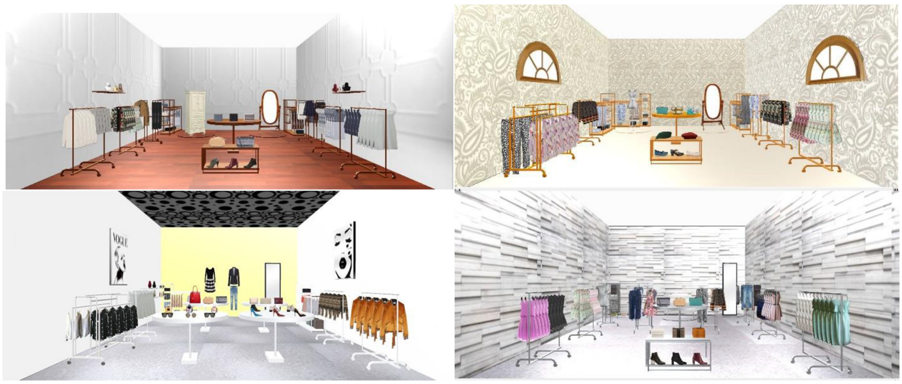

**Figure 2.**
An example of a style module with four options of classic, European, modern and trendy stores in clockwise

perspectives are only reflected in the evaluation of the final design in terms of patronage or buying decisions, the codesign process involves end users early on to make critical decisions in the selection of store atmospherics, product assortments and display methods (see Pantano *et al.*, 2019).

We took an action research approach that includes five phases from diagnosing to specifying learning: (1) diagnosing: we investigated the modular structure of two popular virtual worlds (i.e. Second Life and Sims 4); (2) action planning: we predesigned six modular stores that address both environmental and product presentation features to set up a simplified codesign system; (3) action taking: a total of 170 undergraduate students participated in a codesign process, followed by focus group discussions; (4) evaluation: based on a content analysis of focus group discussions, 17 modules and 207 modular options were identified for personalizing 3D virtual stores; (5) specifying learning: we conceptualized nine modules (i.e. style, price point, product category, color, presence of avatar, virtual product try-on, music, product recommendation and product customization) and 38 modular options (e.g. modern/trendy/classic/European styles, luxury/middle/low-end price points, formal/causal/basic/athletic product categories, warm/neutral/cool/neon/bright colors, etc.) for personalizing 3D virtual stores and finally experimentally visualized 15 modular options using MockShop.

Our research revealed that modularity in virtual worlds offers a wide variety of or in some cases, an infinite variety of design options for nearly all environmental factors. These abundant design choices may benefit dedicated virtual world residents but could be barriers to the average consumer in the retail world who may have limited time and interest in design. An optimal balance of variety and efficiency is the key to successful modularity (Piller *et al.*, 2003; Pine, 1993). Furthermore, though we fully acknowledge the value of exciting shopping experiences that do not necessarily involve aspects of products, a store designed in virtual worlds for the primary purpose of social interaction or entertainment may not be as effective in selling products as a VR store designed solely to engage and entice shoppers because some of the path finding features and many product display, grouping and adjacency methods are largely neglected. Unsatisfactory store design in virtual worlds was thought to contribute to the failures of most big brands to sustain their presence in Second Life (Hassouneh and Brengman, 2015) and was identified as an area for improvement for v-commerce (Xue *et al.*, 2020). Thus, it is critical for VR retailers to learn from those expensive lessons and distinguish their store design from those in virtual worlds.

Subsequently, our research found that student codesigners developed ideas for VR stores modules in all three categories of "pathfinding assistance," "environment" and "manner of product presentation" (Ha *et al.*, 2007). The 17 modules within these three categories can also fit into the three factors that were identified as suited for customization in Krasonikolakis *et al.*'s (2011) study of virtual world atmospherics, which included "store appeal (e.g., storefront, store theatrics, colours, music and graphics)," "innovative atmosphere (e.g., crowding, product display techniques and innovative store atmosphere services)" and "store layout." Krasonikolakis *et al.* (2011) further argued that due to the social presence of multiple avatars in one VR space, the customization capability of certain shared store features is low, such as layout and product display techniques. However, in our study, based on user input, the social presence of an avatar is considered a personalizable factor with options of "no avatar," "personal avatar," "shopping assistant avatar," "inviting friends as avatars" or "avatars of other shoppers." Thus, users can choose whether to share a store environment with friends only or with other shoppers or not to share at all.

Our participants' collaborative ideation of modules and module options resulted in a robust list of modules and modular options that they deem suitable for personalization in the 3D VR shopping environment. Based on their ideation, our research team specified nine modules and 38 modular options as examples to build modularity for personalization, which are no longer confined by the architectural rules (e.g. the presence of avatar as an inherent feature) of virtual worlds as reflected in Hassouneh and Brengman's (2015) and Krasonikolakis *et al.*'s (2011) studies. For instance, in addition to the ability to choose whether or not to share a store space with others, our users desired more freedom in personalizing aspects of the VR store. These modular options call for tapping into the expertise of merchandisers or data mining capabilities to curate personalizable music offerings and product recommendations or assortments, which are similar to but extend 2D website capabilities. Also, as noted by Hassouneh and Brengman (2015) and Krasonikolakis *et al.* (2011), 3D virtual spaces are characterized by innovative store atmosphere factors, such as the user's ability to fly within a store, which could offer exciting and escapist shopping experiences that motivate users to act as engaged shoppers. In conclusion, the modularity configured in our study – backed by the direct input of consumers – combines and transcends the benefits of physical stores, 2D websites and 3D virtual worlds. The actual design of such 3D VR stores should be powered by merchandising, computing, data mining and AI knowledge; however, there are still barriers to overcome to obtain realistic data and models (to simulate realistic scenarios of our environments) and to design comfortable and effective output and interface devices (to enable interactions with the VR space) (see Di Blasi and Pantano, 2015).

## 6. Implications and limitations

The grounded theory approach that our action research employed allowed us to contrast our findings with existing theories in the field of virtual cocreation. In comparison to Nambisan and Nambisan's (2008) and Kohler *et al.*'s (2011) design principles for virtual cocreation systems, the modules that we developed address all the five dimensions of pragmatic, sociability, usability, hedonic and collaborative experiences. However, it seems clear that the aesthetic dimension is also critical in personalization from a consumer's perspective. Modules, such as overall theme, style and color, mostly concern the aesthetic appeal of the VR store and address users' visual preferences. Thus, we suggest adding an "aesthetic" dimension to the design principles for virtual cocreation systems. This development in the theory of virtual cocreation systems coincides with viewpoints expressed in Hassouneh and Brengman's (2015) typology of virtual store atmospherics that argued for the inclusion of functional, aesthetic and entertainment factors in the consideration of 3D virtual world store interiors.

These modules and modular options for personalizing 3D virtual stores identified by our action research and our experimental store visualization contribute to original evidence-based designs that can be readily used by VR retailers and can inspire future exploration and research into 3D VR retail spaces. More important, our exploratory action research and experimental design work based on consumer input contribute a methodological framework for modularity development for 3D VR store personalization. This codesign approach in VR settings can also be useful in learning about user perspectives in the design of physical stores as demonstrated by Wu *et al.* (2015a, b) and Di Blasi and Pantano (2015). Our proposed modular options relate to various aspects of the 3D VR shopping space, such as store interior, product assortment and presentation, in-store advertising, social environment and other essential atmospherics. However, as previously mentioned, many specific features of the 3D VR environment also have the potential for personalization, such as level of interactivity, vividness, realism, immersion and sociability (Jin *et al.*, 2017; Van der Land *et al.*, 2013; Yim *et al.*, 2017), graphics (Papagiannidis *et al.*, 2013), haptic imagery (Huang and Liao, 2017), modality richness (Jin, 2009), landmark design (Liu, 2010), pets and types of entertainment (Hassouneh and Brengman, 2015), content management, transaction, security and privacy, etc. which could be further developed in future research. For instance, users could customize the aspect of immersion and be presented with choices of immersive 3D VR interfaces that are accessed using head-mounted googles and nonimmersive 3D VR interfaces that can be accessed using desktops. Even the types and breeds of pets can be personalized in a VR shopping environment. Further, the degree of realism of pet avatars could be provided as options, e.g. true-to-life, animated or hand-drawn pet avatars. These personalization possibilities not only provide consumers with exactly what they want, how, when and where they want them, but the curated modular choices could also further inspire and entertain consumers (see Caboni and Hagberg, 2019, for more discussions on what values AR provides).

Furthermore, our study provides insight into pedagogical learning relating to 3D VR retailing targeting the new generation of retail professionals. Through active participation in this study of modularity development, visual merchandising students acted as both designers and users. Going through a codesign process themselves, they had to personalize the 3D VR space thinking not only from a design perspective about functionality, usability and the aesthetic of the store environment but also from a user perspective about their own unique needs, preferences and usage contexts. The focus group discussions served to deepen their understanding of the structure of modularity in a 3D VR retail environment: what features are suited to be offered as modules and what kind of modular options are needed? What is the optimal balance between infinite choice and a reasonable and logical number of options? What are other sociability and entertainment features that a 3D VR space could offer? The group setting helps to stimulate collective creativity and collaborative problem-solving. Findings reflected a combination of the real and the imagined: (1) the use of skeuomorphism, i.e. design that mimics the real world (Norman, 2013) and represents physical design properties, such as 3D shape, photorealistic texture, light and shadow based on reality (Kim and Lee, 2020; Bollini, 2017) and (2) new conceptions of navigation and using 3D VR that completely break away from the limitations of the physical world.

One limitation of our study lies in the use of our predesigned modular stores, which did not support cloud collaboration and thus may limit participants' conceptions of what is possible regarding social interactions with others in a virtual environment. Future studies could propose a live modular ecosystem for personalizing 3D VR stores that can be easily used by consumers simultaneously and collaboratively. Also, though we tried to provide consistent instructions for the student codesigners in different visual merchandising classes due to the dynamics of each classroom, the students' experiences were inevitably different, which might influence their conceptions of modular options. We believe more exploratory research and experimentation are needed to better understand consumers' perspectives and to empower consumers to participate in the codesign of, and thus take ownership of, the next generation of retailing interfaces in 3D VR environments. More detailed segmentation of the fashion market can be examined regarding modularity structure, such as product category, price range, etc. Though current studies on 3D VR retailing and marketing are oriented toward a realistic simulation of physical selling spaces with some advanced technological add-ons, most likely under the influence of past success in attracting users in social and gaming virtual worlds, there is still much left to explore and (re)imagine regarding how selling spaces in 3D VR should be configured.

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