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From immersive worlds to virtual showrooms: a taxonomy of virtual reality shopping applications

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The advent of virtual reality (VR) technology and the utilization of electronic commerce (e-commerce) have become prominent features of the contemporary landscape with anticipated growth in the future. Consequently, the concept of shopping in VR has been subject of extensive research, with first consumer applications being now available on the market. The objective of this paper is to create a taxonomy for VR shopping applications, with the intention of providing a framework for the categorization of applications, as well as insights into current market developments. The taxonomy is derived from the findings of a literature review, including 55 studies, and the evaluation of 13 commercial applications. A comparison of research and commercial applications reveals that while research has advanced, commercial applications are predominantly showrooms without purchase possibilities. This discrepancy offers potential avenues for future research to understand the factors influencing companies' reluctance to develop and adopt VR shopping applications.

KEYWORDS

retail, e-commerce, shopping, extended reality, XR, virtual reality, VR, metaverse

1 Introduction

With current advances in hardware and the developments in the course of the metaverse, virtual reality (VR) is evolving from a niche technology to a medium adapted by the mainstream. The potential application areas of VR are numerous and include, but are not limited to, for example, medicine (e.g., Demeco et al., 2023), education (e.g., Bodzin et al., 2021), or architecture (e.g., Portman et al., 2015). One specific domain which has not yet fully exploited the advantages of the technology - but is supposed to be highly influenced by VR in the future - is electronic commerce (e-commerce), i.e., the online purchase of goods and products. While shopping online is an integral part of many people's lives, with about 22% of purchases being conducted online in the US,[1] the lack of overall interest in VR[2] and hardware issues such as screen resolution and hardware bandwidth (Zhan et al., 2020) lead to consumers refraining the technology in the past, making it unattractive for retailers.

1 https://www.digitalcommerce360.com/article/us-ecommerce-sales/, retrieved on 6th of March, 2025.

2 https://www.emergingtechbrew.com/stories/2021/07/07/exclusive-nearly-one-quarter-americans-used-vr-ar-headset, retrieved on 6th of March, 2025.

Hence, the synthesis of VR applications and e-commerce represents a relatively new phenomenon in practice. Existing market applications are more akin to proving the concept of VR shopping, e.g., in virtual show rooms such as the interior designer offered by IKEA[3], rather than providing fully functional environments for e-commerce retailers. However, the findings on this synthesis from literature are promising. VR stores allow to examine products in 3D which enables the user to interact with the products in its dedicated contexts, e.g., furniture in an apartment (Speicher et al., 2018). Through this visualization, VR can have numerous positive effects for retailers, e.g., a higher purchase intention, brand perception, store attractiveness, or word-of-mouth (Cho et al., 2024; Cowan et al., 2021; Jin et al., 2021). Furthermore, VR stores can be used for a variety of products, ranging from groceries (e.g., Schnack et al., 2021b), to clothing (e.g., Lau and Lee, 2019), furniture (e.g., Fiorentino et al., 2022) and tools (e.g., Alzayat and Lee, 2021). Especially entertainment, social aspects, and the users' ability to reinvent themselves are recognized as advantages of virtual shopping compared to 2D websites and offline shopping (Zarifis, 2019). In the business context, VR shopping enables the development of new business models and transforms internal company processes and customer relationships (Mancuso et al., 2023).

Despite the extensive research conducted on VR shopping environments and the anticipated advantages for retailers, a comprehensive, categorized overview of VR retail applications and their characteristics remains absent. Furthermore, there is a lack of understanding regarding the transfer of these positive effects to market applications, both past and present. Thus, as in previous VR studies for other domains, e.g., education (Motejlek and Alpay, 2021), sports (Elsholz et al., 2025), or psychology (Korbel et al., 2021), this study aims to derive this categorization and compare theory and practice based on a taxonomy approach. The taxonomy approach allows to assist researchers and practitioners in comprehending the current landscape of a particular domain and relationships between objects of this domain (Nickerson et al., 2013), in this case VR shopping. Furthermore, it helps to derive implications for both theory and practice. While commercial applications can benefit from the research by gaining insights into effective application designs, research can examine commercial trends that seem to prevail in practice.

In order to achieve this objective, we begin the study by outlining the methodological approach in Section 2. Following the taxonomy methodology, we subsequently conduct a systematic literature review of empirical studies regarding VR shopping, with the aim to categorize existing VR shopping scenarios in theory in Section 3. The resulting tentative dimensions and characteristics form the basis for the taxonomy development, complemented with data from existing VR shopping applications (Section 4). The derived taxonomy allows to establish an understanding of the facets of VR shopping applications while the discussion and comparison of research and practice (Section 5) lead to the identification of several research gaps, which present potential avenues for future research. These research fields, along the paper's conclusion and a presentation of limitations are in Section 6.

3 https://present.digital/ikea/, retrieved on 6th of March, 2025.

2 Materials and methods

The methodology of this paper follows two approaches. The literature review is based on the method of Webster and Watson (2002) while the taxonomy development process is based on Nickerson et al. (2013).

2.1 Literature review process

We conducted a systematic literature review to gain an overview of the current knowledge concerning VR shopping, following the approach outlined by Webster and Watson (2002). This review serves as the foundation for the subsequent taxonomy. The process of literature search and screening is illustrated in Figure 1. Two search interfaces were used for the purpose of literature search: Web of Science and the eLibrary of the Association for Information Systems (AISeL). For both search interfaces, we used the search string in title/abstract/keywords: " ("virtual reality" OR VR) AND (shop* OR retail* OR commerce OR business)". The search string guarantees that each article is pertinent to the subject of virtual reality or its abbreviation "VR", and pertains to shopping or similar terms. In advance of the screening process, we eliminated duplicates (n = 5) from the preliminary sample of identified records (n = 795). In the initial screening process, we excluded 25 records due to their language and availability. Second, we eliminated records published before 2012 (n = 253), as the first commercial HMD, the Oculus Rift, was launched that year (Kushner, 2014) and we excluded records that were not peer-reviewed (n = 50). Third, we excluded additional articles based on three additional exclusion criteria: articles not focusing on VR shopping (n = 325), articles that were not empirical studies (n = 49), and articles not utilizing immersive HMDs (n = 38). Lastly, we conducted a forward and backward search, resulting in five additional studies that were included in the sample. This resulted in a final set of 55 studies. From the final sample, we extracted data through an iterative process. We applied the author-centric approach, as introduced by Webster and Watson (2002), listing the authors and their examined concepts. We derived categories from concepts categorizing the VR shopping environments that we encountered several times in the literature. Special features of VR stores, that were rather rare, were summarized in the category of additional store features.

2.2 Commercial application search process

In constructing the taxonomy, we rely on the guidelines of Nickerson et al. (2013). The taxonomy is based on the results of the systematic literature review and VR shopping applications that are available for VR headsets. In order to identify suitable applications for the taxonomy, we conducted a search on the website Crunchbase.com, the stores for VR applications (Meta and Steam), and Google.com. The application search and selection is illustrated in Figure 2.

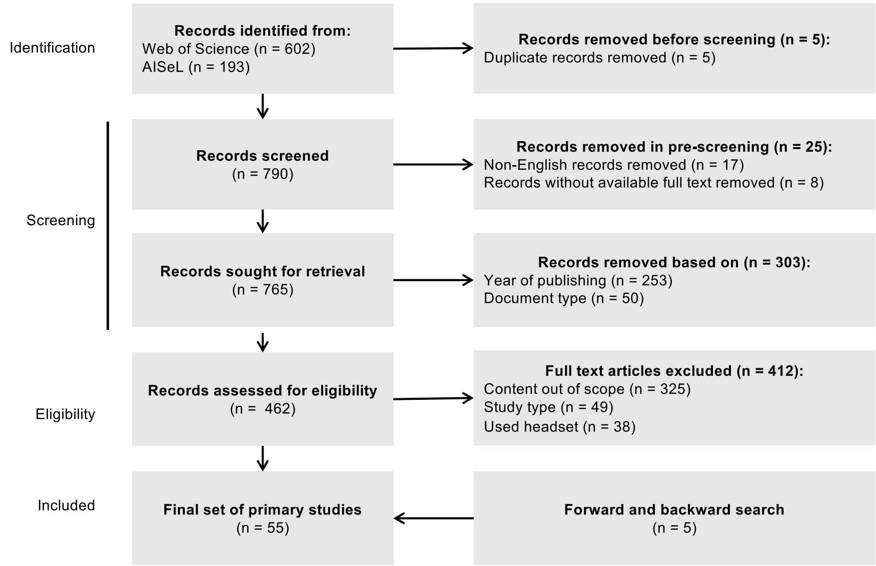

FIGURE 1
Literature selection process.

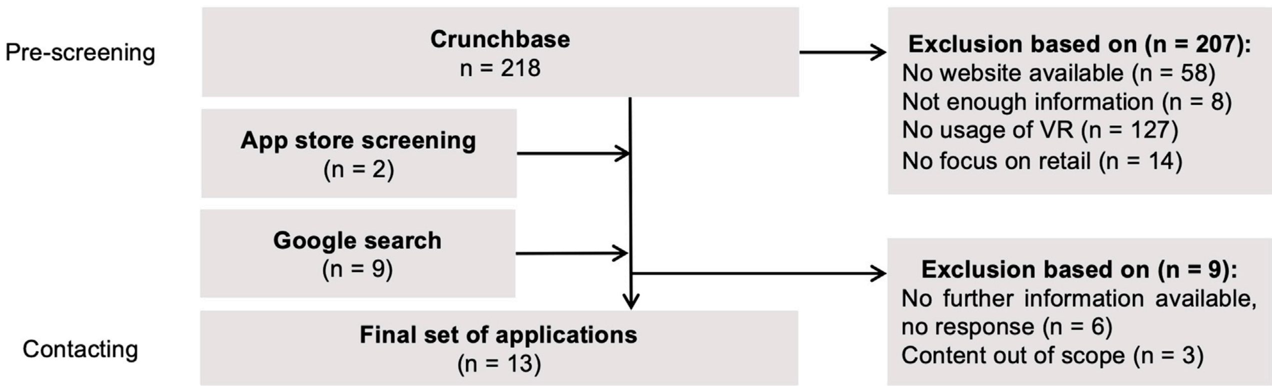

FIGURE 2
Application selection process.

The Crunchbase search employing the search string "Virtual Reality AND (E-Commerce OR Retail)" yielded in 218 companies. The companies were screened and excluded based on the availability of a website (n = 58), the amount of information (n = 8) and the content of their website. In regard to the content, we applied two exclusion criteria pertaining to enterprises not using the technology VR (n = 127) and enterprises that use VR but for different purposes than shopping (n = 14). To facilitate the inclusion of a more diverse range of companies, an additional screening was conducted through app stores (n = 2) and a Google search (n = 9). Subsequently, we contacted the selected enterprises to gain further insight into their projects. In this step, we excluded enterprises based on two criteria. We omitted companies that did not respond or did not provide sufficient information online (n = 6) and those companies whose products were not within the scope of this taxonomy (n = 3). The final taxonomy is based on 13 applications which are described in Table 1. Although the number of available shopping apps is relatively limited, we believe that the remaining applications establish a meaningful taxonomy due to the inclusion of various features from disparate domains and its extendability if new applications appear.

2.3 Taxonomy creation process

According to Nickerson et al. (2013), a taxonomy categorizes objects within a domain based on shared characteristics. The approach to create a taxonomy can be either conceptual (theoretical) or empirical (data-driven). For this taxonomy, we combined the conceptual approach using insights from the

TABLE 1 Final products for the taxonomy.

Id	Product name	Company	Headquater	Description
P1	Ikea VR Experience	IKEA	Netherlands	Immersive kitchen experience where users can interact
P2	Virtual Saturn	Saturn	Germany	Two shopping environments in which technical products are presented
P3	Dyson Demo VR	Dyson	United States	An immersive environment to test the Dyson hairstyle products
P4	Vortic	Vortic	United Kingdom	Social art gallery with different exhibitions
P5	Art Gate VR	Art Gate VR	Canada	Art gallery in metaverse presenting various art
P6	Museum of Other Realities	MOR Museum	Canada	Immersive social art showcase in VR to experience art with others
P7	Magic Reflection	Nationalgalerie Berlin	Germany	Art gallery in VR environment as part of an exhibition
P8	Audi VR Experience	Audi	Germany	Personalized cars for car enthusiasts in VR
P9	Virtual Room Designer	Macy's	United States	A realistic environment where furniture can be placed in
P10	VR Kitchen	Media-Saturn	Germany	Three apartments where personalized kitchens can be configured
P11	Teledomica	Teledomica	United Kingdom	Application to upload 3D models or to place products into your home
P12	ShopR	ShopR	United States	Application to view various stores and buy products
P13	Realistis 1	Realistis	France	Application to build stores and place products

TABLE 2 Ending conditions of a taxonomy according to Nickerson et al. (2013).

Objective ending conditions
All objects/a representative sample of objects have been examined
No object was merged with a similar object/split into multiple objects in the last iteration
At least one object is classified under every characteristic of every dimension
No new dimensions or characteristics were added in the last iteration
No dimensions or characteristics were merged or split in the last iteration
Every dimension is unique and not repeated (i.e., no dimension duplication)
Every characteristic is unique within its dimension (i.e., no characteristic duplication within a dimension)
Each cell (combination of characteristics) is unique and is not repeated (i.e., there is no cell duplication)
Subjective ending conditions
Concise: the number of dimensions/characteristics should be limited to allow the taxonomy to be meaningful
Robust: the dimensions and characteristics provide for differentiation among objects sufficient to be of interest
Comprehensive: all objects/sample of objects within domain of interest are classified/all dimensions identified
Extendible: a new dimension or a new characteristic of an existing dimension can be easily added
Explanatory: taxonomies should contain useful explanations to understand the objects being classified

literature review with the empirical approach involving the classification of the VR shopping applications presented in Table 1. The process of developing a taxonomy comprises three stages. Initially, the meta-characteristics are determined, which define the purpose of the taxonomy. Secondly, both objective and subjective ending conditions need to be determined that must be met to conclude the taxonomy creation process. In present study, we adopt the ending conditions defined by Nickerson et al. (2013), described in Table 2.

Thirdly, the taxonomy is developed through a process of iteration until all ending conditions have been fulfilled. Each iteration can follow one of two approaches: empirical-to-conceptual and conceptual-to-empirical. The empirical-to-conceptual approach identifies a (new) subset of objects, emphasizes common characteristics and groups the characteristics into dimensions. In contrast, the conceptual-to-empirical approach begins with the conceptualization of (new) characteristics and the subsequent examination of objects for

TABLE 3 Concept matrix of relevant literature and their examined concepts.

Authors	Technology	Product type	Environment	Locomotion	Avatar	Additional store features
Alzayat and Lee (2021)	Oculus Rift, controllers	Clothing, tools	Workshop			
Biercewicz et al. (2022)	HTC Vive Pro	Groceries	Grocery store		Other customers	Shopping basket
Kim and Choo (2023)	Oculus, controllers	Clothing	Adidas VR		Personalized avatar	
Branca et al. (2023)	Oculus Quest 2, hand tracking	Milk				Different product packaging
Cowan et al. (2021)	Hand tracking	Champagne	Simple product presentation			
Fiorentino et al. (2022)	Controllers	Furniture	Apartment	Teleportation		Book of material samples
Gil-López et al. (2023)	HTC Vive Pro, controllers, body tracking	Groceries	Grocery store	Free movement		
Gonçalves et al. (2022)	HTC Vive Pro, controllers	Refrigerator	Kitchen	Free movement		Contextualization
Gonçalves et al. (2023)	HTC Vive, controllers	Refrigerator	Apartment			Contextualization
Han et al. (2020)	HTC Vive, controllers	Groceries	Grocery store			
Han et al. (2023)	VR glasses, joystick	Groceries	Grocery store			Shopping basket
Hilken et al. (2022)	VR headset	Food	Cafe			
Jacobsen et al. (2022)	HP Reverb G2 Omnicept, controllers	Groceries	Grocery store	Free movement, teleportation	Salesperson and customers	Shopping basket
Kakaria et al. (2023)	HTC Vive, controllers	Groceries	Grocery store	Teleportation		Shopping basket
Kang et al. (2020)	Oculus Rift, controllers	Furniture	Simple product presentation			
Kim and Ha (2021)	Oculus Quest, wireless controllers	Clothing	D&G Store			
Kinzinger et al. (2022)	HTC Vive Pro, controllers	Kitchen appliances	Kitchen	Free movement		
Lau and Lee (2019)	HMD, controllers, stepping board	Clothing	Boutique	Stepping board		Ambient manipulation
Lee et al. (2022)	Oculus Go, controllers	Clothing	Store			
Liu and Uang (2022)	Oculus Go, controller	Differs	Store	Map picking, cross-zone		Shopping cart
Lombart et al. (2019)	Oculus Rift DK2, controllers, head tracking	Fruits and vegetables	Grocery store	Movement via controller		
Lombart et al. (2020)	Oculus Rift, controllers	Groceries	Grocery store	Movement via controller		
Loureiro et al. (2023)	Oculus Rift	Groceries	Grocery store			
Luangrath et al. (2022)	Oculus Rift	Clothing	Simple product presentation			
Martínez-Navarro et al. (2019)	HTC Vive	Groceries	Grocery store	Free movement		
McCain et al. (2018)	HTC Vive, controllers	Clothing	Simple product presentation	Free movement	Different avatars	
Meirinhos et al. (2022)	HTC Vive Pro, controllers	Refrigerator	Kitchen			Contextualization
Meißner et al. (2020)	HTC Vive, controllers	Cereals	Shelf			
Moghaddasi et al. (2021)	HTC Vive Pro, controllers, body tracking	Groceries, Shoes	Store	Free movement		

(Continued on following page)

TABLE 3 (*Continued*) Concept matrix of relevant literature and their examined concepts.

Authors	Technology	Product type	Environment	Locomotion	Avatar	Additional store features
Morotti et al. (2020)	HTC Vive, controllers, Amazon Echo	Clothing	Store			Smiley assistant
Morotti et al. (2022)	HTC Vive, controllers, Amazon Echo, body tracking	Clothing	Store		Avatar for user and sales-person	Try-on
Naderi et al. (2020)	Oculus Rift, X-Box Controllers	Camera	Simple product presentation	Movement via controller		
Park and Kim (2023)	HTC Vive	Clothing	Store			Try-on
Pengnate et al. (2020)	Oculus Rift	Drinks	Apartment		Robot assistant	
Peukert et al. (2020)	HTC Vive, controllers	Cereals	Shelf	Teleportation		Shopping basket
Peukert et al. (2019)	HTC Vive, controllers	Cereals	Shelf	Free movement		Shopping cart
Pizzi et al. (2019)	HTC Vive, controllers	Groceries	Grocery store			Shopping cart
Plechatá et al. (2019)	HTC Vive, controllers	Groceries	Grocery store	Free movement, teleportation		
Ricci et al. (2023)	Oculus Quest 2, controllers	Clothing	Boutique	Point and teleport		
Saffari et al. (2023)	HTC Vive	Groceries	Grocery store	Free movement, teleportation		
Schnack et al. (2021b)	HTC Vive, controllers	Groceries	Grocery store			Shopping basket
Schnack et al. (2019)	Controllers, body tracking	Groceries	Grocery store	Free movement, teleportation		Shopping basket
Schnack et al. (2021a)	HTC Vive, controllers, motion tracking	Groceries	Grocery store	Teleportation		
Schnack et al. (2020)	HTC Vive, controllers, lighthouse tracking	Groceries	Grocery store	Lighthouse		Shopping basket
Siegrist et al. (2019)	HTC Vive, controllers, hand and eye tracking	Cereals	Shelf			Shopping cart
Speicher et al. (2018)	HTC Vive, controllers, lighthouse tracking	Furniture	Apartment	Free movement, point and teleport		Shopping cart
Su et al. (2020)	HTC Vive	Furniture		Free movement, teleportation		
van Berlo et al. (2021b)	HTC Vive, controllers	Chocolate	Apartment			
Verhulst et al. (2018)	Oculus CV1, controllers	Groceries	Grocery store	Free movement	Avatars of different sizes	
Wölfel and Reinhardt (2019)	HTC Vive	Wine, milk	Different scenes			Contextualization
Wu et al. (2019a)	HTC Vive	Clothing	Store			
Wu et al. (2019b)	HTC Vive, controllers	Clothing				
Xi et al. (2023)	Valve Index	Music	Record shop			
Yuan et al. (2023)		Clothing	Taobao Buy + platform			
Zhao et al. (2018)	HTC Vive, controllers	Groceries, books	Grocery store/book store		Virtual store assistant	

these characteristics and dimensions. In each iteration, new dimensions and characteristics are included if (1) the regarded application does not fit into the current taxonomy or (2) new dimensions appear that are needed to distinguish between applications. Both approaches converge in the final step where the ending conditions are checked. If both objective and subjective ending conditions are met the taxonomy is concluded. Otherwise, a new iteration must be performed (Nickerson et al., 2013).

The objective ending conditions can be readily ascertained due to the clarity of the criteria. However, in order to assess the subjective ending conditions, it was necessary to develop alternative metrics. To ensure the conciseness of the taxonomy, we limited the number of categories to 5 and the number of dimensions to 20 to avoid overwhelm. On the other hand, we checked the taxonomies robustness and extendability by checking its applicability with three shopping apps running on desktop VR. All applications could be classified according to the final taxonomy. The comprehensiveness and explainability of the taxonomy were verified through two expert interviews based on the final taxonomy.

3 Literature review

The objective of the literature review is to create a theoretical foundation for the subsequent taxonomy development. For our analysis, we adhered to the guidelines by Webster and Watson (2002). Accordingly, the 55 selected studies are classified into categories in a concept matrix, as illustrated in Table 3.

3.1 Technology

The first section deals with the technological foundation including output and input devices. For the output devices, different technologies are available. The first category are visual output devices, such as HMDs, haptic, and multi-sensory output devices. In the examined studies, HMDs from HTC have been the most common (31 studies). Most studies relied on the base version of HTC Vive, while some studies worked with the HTC Vive Pro, which can be used wireless and has a higher display resolution (6 studies, e.g., Gil-López et al., 2023; Biercewicz et al., 2022). Other studies used the Oculus HMDs Oculus CV1 (Verhulst et al., 2018), Oculus Rift (8 studies, e.g., Lombart et al., 2019; Loureiro et al., 2023), and Oculus Quest (3 studies, e.g., Ricci et al., 2023). As an input device, the majority of the studies relied on handheld controllers to allow users to manipulate the environment (38 studies, e.g., Peukert et al., 2020; Schnack et al., 2020). For the purpose of navigation, Lau and Lee (2019) used a stepping board to allow users free movement in the store without having to rely on a comparatively large room. However, many participants reported feeling dizzy and unstable on the board. Other studies relied on Amazon Echo (Morotti et al., 2020; Morotti et al., 2022) to record users' verbal instructions. Most of the modern HMDs include tracking devices for head, hand, eye, and body movements. In the literature reviewed, these features have been utilized in different ways. In some cases, hand-tracking has been used to observe users' gestures, for example, when picking a product (e.g., Siegrist et al., 2019). Other studies tracked the whole body and posture to mirror their body through an avatar (Morotti et al., 2022; Verhulst et al., 2018) or at least the direction and distance participants move (Schnack et al., 2019; Schnack et al., 2021a). Data from eye, hand and head movements can be combined to infer shoppers' impulsivity (Moghaddasi et al., 2021) or their information-seeking behavior (Siegrist et al., 2019). Lastly, Schnack et al. (2020) and Speicher et al. (2018) relied on a special tracking technique called lighthouse tracking, which allows users to move freely within the field of view of a base station.

3.2 Product type

The type of product is explicitly mentioned in almost all the studies examined. Two types of products were encountered most: groceries (19 studies, e.g., Biercewicz et al., 2022; Gil-López et al., 2023) and clothing (14 studies, e.g., Kim and Ha, 2021; Lau and Lee, 2019). Groceries are suitable for VR shopping experiments because the type and healthiness of products selected by the user can be analyzed (4 studies, e.g., Biercewicz et al., 2022; Lombart et al., 2020). Offering a wide range of products in an environment makes it possible to track user decisions to, e.g., to analyze in which shelf and at what height the chosen products were located (Gil-López et al., 2023; Schnack et al., 2020). However, many participants did not exhibit excitement due to the rather mundane nature of grocery shopping (Schnack et al., 2021a). The main arguments for research on VR fashion environments are the rapid development of the online fashion industry (Morotti et al., 2020; Morotti et al., 2022) and a better visualization of clothing than in conventional online shops (Liu et al., 2020). Park and Kim (2023) found that virtual try-ons increased the cognitive elaboration and purchase intentions compared to 3D virtual stores and static images. Other studies presented furniture or kitchen appliances to customers (8 studies, e.g., Fiorentino et al., 2022; Gonçalves et al., 2022). Furniture is particularly suitable for VR applications since it can be presented in a natural environment, like an apartment (Speicher et al., 2018). Some applications do not offer a collection of different products, but instead only one product in different variations. A very suitable product type for this is cereals (4 studies, e.g., Meißner et al., 2020; Peukert et al., 2019) since the low involvement in the habitually purchased product leads to a rather simple decision-making process (Peukert et al., 2020). Additionally, cereals are straightforward to conceptualize in three dimensions, and customers can relate to this product category (Peukert et al., 2019). The same advantages apply to milk (Branca et al., 2023; Wölfel and Reinhardt, 2019). In contrast to simple 3D models of cereals or milk, cameras have more options to use high-level design cues. As demonstrated by Naderi et al. (2020), highly detailed products increased the perceived aesthetics and affective response of customers in comparison to low-level camera design. The examination of fruits and vegetables can facilitate the study of customer perceptions of misshapen goods. Lombart et al. (2019) discovered that the appearance and quality of heavily misshaped fruits and vegetables are perceived less favorably than standard fruits and vegetables in a VR supermarket. The findings of Alzayat and Lee (2021) reveal that a VR environment is more conducive to the presentation of tools than clothing. This suggests that extensions of the body are readily comprehensible in VR than presentations of the body. Other single-product applications offer champagne (Cowan et al., 2021), chocolate (van Berlo et al., 2021a), or wine (Wölfel and Reinhardt, 2019), i.e., more luxurious commodities.

3.3 Environment

While numerous studies have employed store environments that are closely aligned with the specific product type under consideration, for instance, groceries in a supermarket or clothing in a boutique, others did not implement conventional store layouts. Instead of implementing their own storefront, in some studies it was decided to utilize preexisting stores. For example, Kim and Ha (2021) used a D&G store and Yuan et al. (2023) employed the Taobao Buy + platform. Other studies implemented their own environments. In addition to conventional stores, some applications feature a single shelf instead of a store (4 studies, e.g., Siegrist et al., 2019; Wölfel and Reinhardt, 2019), offering a single product category, mostly cereals, wine, or milk (e.g., Wölfel and Reinhardt, 2019). The use of a shelf with a single product type facilitates the comprehension of participants' decisions in comparison to a complex supermarket environment. An alternative approach is to present products in a variety of environments rather than in a single store. For example, products can be presented in a neutral environment, such as on top of a table or in an empty room (5 studies, e.g., McCain et al., 2018; Naderi et al., 2020). Alternatively, products can be integrated into their natural environment, such as tools in a workshop (Alzayat and Lee, 2021), kitchen appliances in a kitchen (Kinzinger et al., 2022), or furniture in an apartment (4 studies, e.g., Fiorentino et al., 2022; Gonçalves et al., 2022). As demonstrated by Wölfel and Reinhardt (2019), placing a wine bottle in the context of a wine yard can enhance product promotion, particularly in comparison to an empty environment or a simple shelf in a retail store. Such realistic placements facilitate the visualization of products in an apartment setting, as illustrated by Speicher et al. (2018), in the context of furniture shopping.

3.4 Locomotion

The manner in which customers move through a VR store is contingent upon the technology employed, particularly in regard to hand tracking and controllers. The primary distinction between these approaches is whether customers are permitted to walk in the real world or stay in a fixed location. The most natural method of locomotion is to allow participants to move freely, with sensors translating these signals and adjusting the VR perspective accordingly (14 studies, e.g., Gil-López et al., 2023; Moghaddasi et al., 2021; Plechatá et al., 2019). The areas in which the participants are permitted to move freely may vary in size, for example, 3 m by 2 m (Verhulst et al., 2018), or up to 6 m by 6 m (Moghaddasi et al., 2021). However, the surroundings limit how far customers can move. Walls or signal range constrain on the extent of customer mobility. Furthermore, it is possible that participants may venture beyond the designated safe area due to a lack of awareness of their surroundings (Gonçalves et al., 2022). In order to track the movement of their participants, Lau and Lee (2019) used a stepping board, which enabled the participants to move in any direction while remaining stationary within the laboratory. In some cases, the available space is insufficient to permit unrestricted movement, or users may be unable to move because of their age. One potential solution to this problem is the use of teleportation as a locomotion technique (10 studies, e.g., Fiorentino et al., 2022; Peukert et al., 2019), or alternatively, a combination of free movement and teleportation (6 studies, e.g., Schnack et al., 2019; Su et al., 2020). Teleportation is a technique whereby a point within the environment is selected as a target and the user is instantly teleported to that location. One potential teleportation method is the "point and teleport" approach (Ricci et al., 2023; Speicher et al., 2018) wherein users can designate a specific point as their destination. In their study, Liu and Uang (2022) implemented a map where users could select their destination and teleport there. However, Schnack et al. (2021a) were unable to detect any differences in engagement, excitement, stress, or purchase attributes when comparing motion-tracked walking and instant teleportation. Some studies used the thumb sticks of controllers for movement, thereby enabling participants to remain seated while simultaneously navigating through the environment (Naderi et al., 2020; Lombart et al., 2019; Lombart et al., 2020).

3.5 Avatar

The review of the literature revealed that avatars were employed for a variety of purposes. On the one hand, the user itself was embodied by an avatar when using the shopping applications (4 studies, e.g., McCain et al., 2018; Morotti et al., 2022). On the other hand, some applications utilized avatars as salespersons or other customers within the stores (5 studies, e.g., Biercewicz et al., 2022; Jacobsen et al., 2022). In their studies, McCain et al. (2018) and Verhulst et al. (2018) investigated the impact of various user avatar characteristics on their behavior. Their findings suggest that a Kim Kardashian avatar may foster narcissistic tendencies in users, while obese avatars do not appear to influence the healthiness of purchased products or the perceived healthiness of products. In their respective study, Morotti et al. (2022) employed personalized avatars with the objective to of archiving a high degree of user similarity. In order to enhance the realism of their supermarket applications, Biercewicz et al. (2022) and Jacobsen et al. (2022) employed avatars to portray other customers within the virtual store. However, Jacobsen et al. (2022) observed that users visiting the supermarket perceived other customers to be less aware, conscious, or alive. In addition to the use of avatars as a representation of users and other customers, four studies have employed avatars as salespersons or assistants (e.g., Jacobsen et al., 2022; Morotti et al., 2020). Two potential methods for implementing such assistants are through the use of a smiley (Morotti et al., 2020) or a robot (Pengnate et al., 2020) that can provide additional information and avenues for interaction.

3.6 Additional store features

In addition to products, environments, and avatars for entities in the stores, some applications have included additional store features. For example, numerous applications include a realistic shopping cart (5 studies, e.g., Liu and Uang, 2022; Peukert et al., 2019) or a shopping basket (8 studies, e.g., Peukert et al., 2019; Schnack et al., 2019). To facilitate a more naturalistic furniture shopping experience, Fiorentino et al. (2022) provided a tangible book of

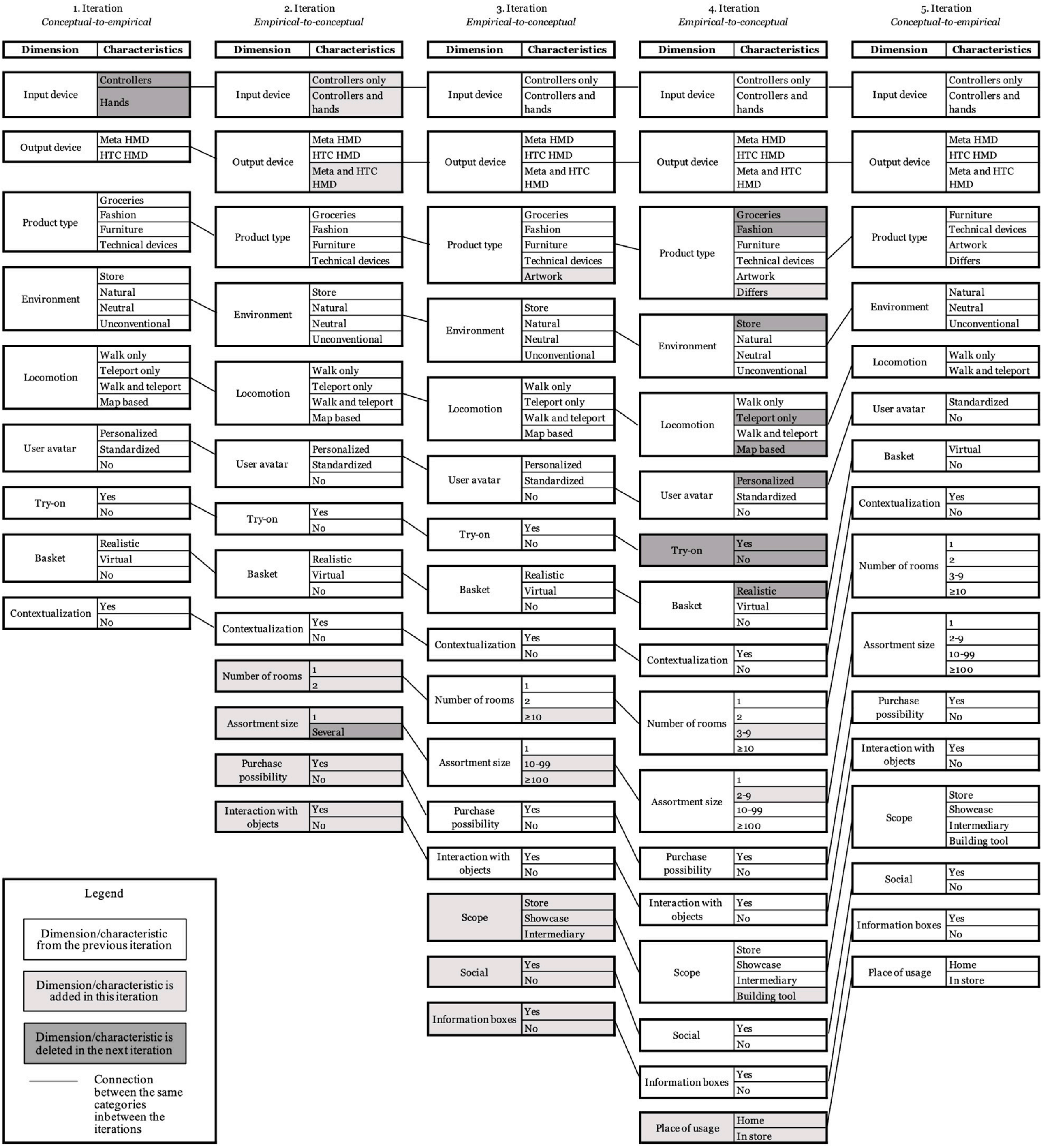

FIGURE 3
Iterative process of creating the taxonomy.

material samples that could be touched during the exploration of furniture in VR. The utilization of multi-sensory feedback afforded the user the benefit of reducing the risks of an afterthought and allowed them the perception of engaging and novel experiences. In their study, Lau and Lee (2019) employed ambient manipulation techniques, specifically changes in music and lightening, to enhance consumers' purchase intention. Their findings suggest that providing an interactive and hedonic apparel shopping experience can positively influence consumer behavior. Some of the examined studies selling clothing offer the possibility of trying them on (Morotti et al., 2022; Park and Kim, 2023). This affords the advantage of being able to imagine how the garnets might appear in real life. Morotti et al. (2022) developed a system with floating clothing items that could be selected, tried on, and viewed in a mirror. Other studies have employed contextualization to ascertain whether an empty or filled refrigerator has an influence on users

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(Gonçalves et al., 2022; Gonçalves et al., 2023; Meirinhos et al., 2022; Wölfel and Reinhardt, 2019). The study by Meirinhos et al. (2022) did not identify a significant correlation between contextualization and either purchase intention or user satisfaction. Similarly, Gonçalves et al. (2022) could not identify a significant relationship between contextualization and how users are informed about product functionalities, their size, remembering details, or users' workload. Contextualization was also employed by Wölfel and Reinhardt (2019) in a comparative study. Products were placed in two distinct contexts: One that was deemed suitable, such as a wine bottle in a wine cellar, and one that was deemed unsuitable, such as wine on a ski slope. They could observe higher product ratings in the contexts that were deemed more fitting.

4 Taxonomy creation

The objective of the present study is to construct a taxonomy of VR shopping applications. The process of developing the taxonomy comprises five iterations, during which temporary dimensions and characteristics are established. These iterations are depicted in Figure 3. To prevent oversights resulting from attempting to assess all applications in a single iteration and to be able to screen all applications in-depth, we elected to examine the applications in our database in several iterations.

As previously stated, the initial phase of taxonomy development is the determination of meta-characteristics that are intended to support the purpose of the taxonomy and align with the anticipated usage by its users. For this taxonomy, the meta-characteristic is defined as "virtual reality shopping applications running on head-mounted displays". In the second step, the objective and subjective ending conditions are determined by adapting those listed in Table 2. In the following section, we outline the iterative procedure employed to derive the final taxonomy.

4.1 Iterations

4.1.1 Iteration 1

Our first iteration is based on the conceptional-to-empirical approach, given the robust database the literature review provides. We use all categories from the literature review to derive the initial dimensions and transform the most prevalent features of the literature categories into characteristics for the dimensions. With regard to the taxonomy, we divide the technology category into input (hands/controllers) and output devices (Meta HMD/HTC HMD). The third dimension, product type, encompasses a range characteristics, including groceries, fashion, furniture, and technical devices. Additionally, we could encounter four distinct types of environments: conventional stores, natural product environments, neutral environments, and unconventional environments not specifically related to the presented products. The fifth dimension, locomotion, is comprised of three primary characteristics: walk only, teleport only, and map-based locomotion. It should be noted that some applications combine walking and teleportation. User avatars, either personalized, standardized, or not implemented, form the sixth dimension. The category of additional store features is divided into three dimensions: try-on (yes/no), basket (realistic/virtual/no), and contextualization (yes/no). Given the introduction of new dimensions and characteristics in this iteration, we need to perform another iteration.

4.1.2 Iteration 2

In the second iteration, we change the approach to empirical-to-conceptual, deriving dimensions and characteristics from existing products. We selected three products from the database for our analysis, beginning with early VR shopping applications: P1 (Ikea VR Experience), P2 (Virtual Saturn), and P3 (Dyson Demo VR). These products are promising due to the diversity of their product types and environments. Prior to further examining the applications, it became evident that they operate on distinct devices: While P1's and P3's output device is a Quest HMD, P2 is compatible with the now obsolete Rift and HTC Vive headsets. Moreover, the dimensions of the input device require modification. While P1 permits input through controllers and hands, P2 and P3 are restricted to controller input. Additionally, the number of products differs between the applications. P1 presents a single kitchen in a single room, that can be customized in several ways but not purchased within the VR store. In contrast, P2 presents a diverse range of different technological devices across two rooms with the option of adding items to a list for future purchase. P3, in contrast, presents an array of hairstyle products with customization options for demonstration purposes. This requires the introduction of a new dimension for the number of rooms, assortment size and for the possibility of purchasing items. All three applications have in common that users can interact with the offered goods. P1 allows the user to open kitchen drawers and place a pan on the stove. P2 allows users to grab the products with their virtual hands, turn them or throw them in the air. P3 invites the user to use the devices on sample hair wigs. Therefore, interactions are introduced as a new dimension. As new dimensions were added in this iteration, we need to perform another iteration.

4.1.3 Iteration 3

For the third iteration we take the same approach as for the second iteration, as further VR shopping applications should be inspected. In this iteration, we select a few art galleries for further consideration: P4 (Vortic), P5 (Art Gate VR), P6 (Museum of Other Realities), and P7 (Magic Reflection). In contrast to the previously examined applications, these applications have different focuses. Such platforms are used by galleries and artists alike for the purpose of selling or presenting their artworks to the general public. It is thus necessary to introduce a new characteristic for the dimension product type for artwork. Furthermore, the galleries exhibit notable differences from the previous applications in terms of the number of rooms and the assortment size, with larger dimensions for P4, P5, and P6. These dimensions hence need to be updated in this iteration. P4 and P5 function as intermediaries: These applications do not engage in direct sales but facilitate connections between customers and sellers through an inquiry form. P6 and P7 present art created by a selected list of artists. Consequently, a new dimension for the application' scope is introduced to differentiate between stores, intermediaries, or applications solely using their store as a showcase for their products without the option of purchasing their products inside

TABLE 4 Final taxonomy containing all products.

category	Dimension	Characteristics	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
Technology	Input device	Controllers only		•	•		•	•	•	•	•	•	•	•	•
		Controllers and hands	•			•									
	Output device	Meta HMD	•		•	•	•	•	•				•	•	
		HTC HMD								•	•	•			•
		Meta and HTC HMD		•											
	Locomotion	Walk only			•					•	•		•		
		Walk and teleport	•	•		•	•	•	•			•		•	•
Store purpose	Product type	Furniture	•								•	•	•		
		Technical devices		•	•					•					
		Artwork				•	•	•	•						
		Differs												•	•
	Scope	Store		•											
		Showcase	•		•			•	•	•	•	•			
		Intermediary				•	•						•	•	
		Building tool													•
	Place of usage	Home	•	•	•	•	•	•	•			•	•	•	•
		In store								•	•				
	Puchase possibility	Yes		•		•								•	
		No	•		•		•	•	•	•	•	•	•		•
	Interaction with objects	Yes	•	•	•			•		•		•	•	•	
		No				•	•		•		•				•
Store size	Number of rooms	1	•		•						•		•		•
		2		•											
		3–9							•	•		•			
		≥ 10				•	•	•						•	
	Assortment size	1	•												
		2–9			•										•
		10–99		•			•	•	•	•		•			
		≥ 100				•					•		•	•	
Store design	Environment	Natural	•			•			•	•	•	•	•	•	
		Neutral			•		•								•
		Unconventional		•				•							
	Contextualization	Yes	•	•	•	•		•	•	•	•	•	•	•	
		No					•								•
	Information boxes	Yes		•	•	•	•						•	•	
		No	•					•	•	•	•	•			•
	Basket	Virtual		•										•	
		No	•		•	•	•	•	•	•	•	•	•		•

(Continued on following page)

TABLE 4 (*Continued*) Final taxonomy containing all products.

category	Dimension	Characteristics	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13
Social aspects	Social	Yes				•	•	•						•	
		No	•	•	•				•	•	•	•	•		•
	User avatar	Standardized				•	•	•						•	
		No	•	•	•				•	•	•	•	•		•

P1, Ikea VR; P2, Virtual Saturn; P3, Dyson Demo VR; P4, Vortic; P5, Art Gate VR; P6, Museum of Other Realities; P7, Magic Reflection; P8, Audi VR Experience; P9, Virtual Room Designer; P10, VR Kitchen; P11, Teledomica; P12, ShopR; P13, Realistis 1.

the VR environment. Moreover, P4, P5, and P6 facilitate social experiences. They allow any number of individuals in their digital galleries to view and interact with each other. This observation results in the introduction of a new dimension, namely, whether the product includes social interaction or not. Additionally, the applications include a lot of information about the products in text boxes, introducing another new dimension: the existence of product information boxes that provide context to the displayed objects. In this iteration we have added new dimensions, which necessitates the introduction of another.

4.1.4 Iteration 4

The fourth iteration employs the same approach as the previous ones. In this iteration, we inspect the remaining six applications P8 (Audi VR Experience), P9 (Virtual Room Designer), P10 (VR Kitchen), P11 (Teledomica), P12 (ShopR), and P13 (Realistis 1). Firstly, the product type dimension requires updating, as P12 and P13 cannot be assigned to an existing characteristics, given that they offer various goods of different categories. Two existing dimensions - number of rooms and assortment size - also require revision. P8 comprises three rooms, which leads to the creation of a new characteristic pertaining to the number of rooms. Furthermore, P13 only offers a limited range of products, leading to a new characteristic for the assortment size. Two of the products under examination, P8 and P9, cannot be used at home. Instead, customers are required to visit a participating brick-and-mortar store in order to test the application. This introduces a new dimension for the place of usage, which can be either at home or in a store. In contrast to all other products, P13 is employed as a store design tool rather than a store or showcase itself. Therefore, the dimension scope must be updated with a new characteristic for store building tools. Since dimensions were added in iteration 4, another iteration is necessary.

4.1.5 Iteration 5

As we inspected all products from the database in the previous iterations, the approach adopted in this iteration is conceptual-to-empirical. This allows us to revise all dimensions and characteristics with a view to eliminate unnecessary parts. In this iteration, the existing dimensions are verified. The products under examination were found to sell either furniture, technical devices, or artworks. Therefore, the product type dimension must be revised and other product types must be deleted. Furthermore, none of the analyzed applications incorporated a store environment. Alternatively, they may be classified as natural, neutral, or special. The next dimension retrieved is locomotion. The examination revealed that none of the analyzed applications offer teleport only or map-based locomotion, which are thus removed from the taxonomy. Further, the user avatar dimension requires further revision: None of the products utilizes personalized avatars, this dimension is thus excluded. The dimension of try-on is superfluous, as fashion items were not available for purchase in any of the applications. Therefore, a virtual try-on is not a viable option. Ultimately, the characteristic of realistic shopping carts must be eliminated, as no application employs this feature. In the previous iteration, no new dimensions were added, no dimensions or characteristics were combined and all objects available were examined. All cells are unique and not repeated. Furthermore, the resulting taxonomy achieves a balance between conciseness and robustness. It is comprehensive and all dimensions are explained. Should new applications appear on the market, the taxonomy can easily be revised by the addition of new dimensions and characteristics. Therefore, all ending conditions are met and the taxonomy development process concludes successfully.

4.2 Final taxonomy

The iteration 5 has led to the final taxonomy which is presented and explained in the following. Table 4 illustrates the final taxonomy, which includes the classification of all commercial applications.

4.2.1 Technology

The technology category pertains to the technical foundations and methods utilized by VR stores. In order to interact within VR stores, users are required to utilize input and output devices. The majority of products use controllers only (n = 11), less also permit hand gestures (n = 2). Two output devices were encountered often: Meta HMDs (n = 8) and HTC HMDs (n = 4). A single product has been designed for both systems (n = 1). Another technology-related aspect is the locomotion employed in the applications. The majority of products allow for both walking and teleporting (n = 9), while a minority lack teleportation capabilities, with users restricted to navigating through the stores by physical walking (n = 4).

4.2.2 Store purpose

In the next step of the analysis, we examined the store purpose. The majority of stores offer furniture (n = 4) and artworks (n = 4), while a smaller number offer technical devices (n = 3). Two applications offer a variety of product types (n = 2). The stores exhibit different scopes, encompassing a store (n = 1), a showcase room without purchase possibility (n = 7), or an intermediary for others to promote their products (n = 4). One application does not offer products but can be used as a building tool for stores (n = 1). The majority of the applications can be used at home and are freely

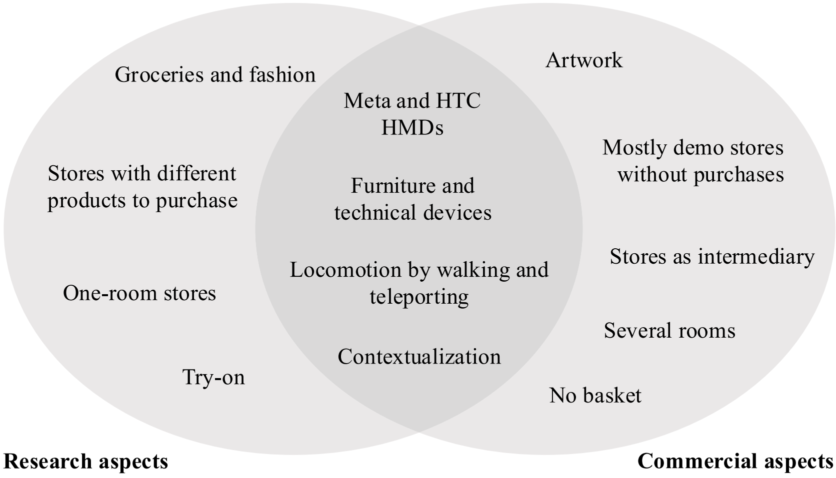

FIGURE 4
Venn diagram of research and commercial VR stores.

available (n = 11), while a minority of applications are confined to physical brick-and-mortar stores (n = 2). Only a minority of applications allow purchasing products directly in the associated stores (n = 3), whereas the remaining do not provide this functionality (n = 10). Ultimately, over half of the applications facilitate interaction with their products, such as opening furniture or grabbing products (n = 8). In the remaining applications, the items and stores are static (n = 5).

4.2.3 Store size

Regarding the store size, the majority of the stores only included a limited number of rooms, while only four applications encompass at least 10 rooms (n = 4). The remaining stores have only one room (n = 5), two rooms (n = 1), or three to nine rooms (n = 3). In comparison to the number of rooms, the applications offer a considerable range of products. The majority of the applications have an assortment size of 10–99 products (n = 6), with a few having more than 99 (n = 4). One application features a single product (n = 1), while further applications offer two to nine products (n = 2).

4.2.4 Store design

After establishing the store's purpose and size, specific design decisions need to be addressed. The design of a store is a crucial aspect of its overall functionality and appeal. The majority of considered applications utilize natural environments, which are aligned with the characteristics of the offered product type (n = 8). The second most frequently encountered environment are neutral environments with limited stimuli (n = 3). Two applications implemented an unconventional environment, which we define as environments that deviate from the norm for the offered product type (n = 2). Contextualization refers to the manner in which stores provide support for presented products by promoting the product type through the environment. The majority of applications employ contextualization (n = 11), while a minority do not utilize this concept (n = 2). Some of the VR shops support decision making by providing additional information in customizable boxes (n = 6). However, the majority of the applications do not offer further product information (n = 7). With regard to the integration of shopping carts or baskets, only two applications integrated such into their application (n = 2), while the remaining applications lack this feature (n = 11).

4.2.5 Social aspects

The social aspects of VR shopping pertain to the integration of users into the shopping environment and their interactions with others. The first dimension determines whether products encompass social aspects, that is, whether users can see and interact with others. Only a small number of applications are social (n = 4), while the majority of applications are used by a single user (n = 9). Among those with social interaction, standardized user avatars have been implemented (n = 4), whereas the remaining applications do not utilize avatars (n = 9).

5 Discussion

The taxonomy revealed several similarities and discrepancies between theory and practice, as depicted in Figure 4. In context of the technology used for VR shopping experiences, both researchers and practitioners have demonstrated a clear preference for HMDs from leading brands such as Oculus/Meta and HTC. This preference aligns with current headset market statistics, which indicate a high level of acceptance and adoption within the industry (e.g., Steam[4]). These brands are noted for their high-definition visual performance, robust tracking capabilities, and extensive support for developers. These qualities are indispensable for the creation of immersive and interactive virtual environments that are necessary for a realistic and engaging VR shopping experience. The preference for these HMDs in academic research and commercial deployments indicates a

4 https://store.steampowered.com/hwsurvey/Steam-Hardware-Software-Survey-Welcome-to-Steam, retrieved on 6th of March, 2025.

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consensus on their effectiveness in delivering VR experience as of now (46 research apps and 13 commercial apps).

Similarities also occur in the categories of products offered: furniture (8 research apps and 4 commercial apps) and technical devices (4 research apps and 3 commercial apps) are commonly offered by VR stores in both theoretical studies and practical implementations. Examples such as Virtual Room Designer and VR Kitchen encourage users to place a variety of items within a room. The popularity of furniture in VR could be due to the ability of the technology to visualize items within contextual environments, herby enhancing the customer's ability to envision how specific pieces would appear and integrate within a real-life setting. This realistic visualization facilitates more informed purchasing decisions. Technical devices, such as the hair stylers in Dyson Demo VR, are well suited for presentation using VR technologies as well. Given the sophisticated nature of VR technology, it is unsurprising that it appeals to individuals with a general interest in various technology products. This alignment in product type preferences across studies and commercial implementations demonstrates an intuitive match between VR capabilities and the products that derive the greatest benefit from immersive visualization and interaction.

A locomotion technique that is prevalent in both domains is combination of teleporting and enabling physical movement by the user (6 research apps and 9 commercial apps). The capability to transform physical actions into a virtual environment is a main characteristic of virtual reality, present across diverse VR settings, ensuring a authentic and immersive experience (Pasch et al., 2009). Adding the possibility to teleport guarantees that users with limited space can navigate freely within the VR space.

Another similarity is the usage of contextualization, meaning the adaption of environments to complement the product (13 research apps and 11 commercial apps). This is particularly effective in scenarios where furniture or small technological devices are displayed within apartments, such as in Ikea VR and Teledomica, or in any other residential settings, creating a realistic and natural environment for customers that enables their ability to imagine these products in their own homes. This method not only leverages the capabilities of VR, but also directly assists consumers in making informed purchasing decisions by placing products in an appropriate and relatable context.

In addition to the parallels between theory and practice, a number of discrepancies could be identified. With regard to the types of products sold, aside from furniture and technical devices, stores in literature frequently concentrate on groceries or specific foods and drinks (30 research apps and 0 commercial apps), and fashion as well (14 research apps and 0 commercial apps). One potential explanation for the absence of VR shopping applications that focus on groceries is that products sold in supermarkets are typically categorized as low-involvement, implying that customers generally do not form strong emotional connections the products they purchase regularly (Celsi and Olson, 1988; Gbadamosi, 2009). Such products may therefore be of little interest to users of commercial shopping platforms and hence not implemented by retailers. In the domain of fashion, the primary challenge is the development of effective virtual try-on technologies. As demonstrated by Liu et al. (2020), customers prefer AR try-on of clothing over VR-based solutions. Therefore, the concept of VR try-on remains a theoretical concept and requires further development before meeting market expectations effectively.

On the other hand, commercial applications introduce a product type that is not extensively covered in the literature review. Within the database for the taxonomy, we identified a number of galleries, like Museum of Other Realities and Magic Reflection, that either sell or promote artwork (0 research apps and 4 commercial apps). In the context of commercial applications, this is logical considering the relatively simple process of converting physical paintings into their 3D counterparts in VR environments. As stated by the VR galleries, a few high-resolution pictures are sufficient to create a realistic virtual representation of artworks. This approach not only enhances the visual engagement but also facilitates greater accessibility to art by overcoming boundaries of physical galleries. It enables users to experience and interact with art in immersive settings and creative ways that are challenging to implement in traditional environments.

In terms of the store types, theoretical studies frequently focus on natural and traditional store settings. These include grocery stores or boutiques, which aim to replicate everyday shopping experiences in a virtual format (32 research apps and 0 commercial apps). Commercial applications, in contrast, frequently offer environments for showcasing products in virtual settings, such as prototypes or promotional marketing campaigns (0 research apps and 7 commercial apps). Examples include IKEA VR, Audi VR, Dyson Demo VR and VR kitchen. These platforms are typically utilized for the purpose of virtual product demonstrations rather than traditional shopping venues. Another popular store type are applications that serve as facilitators or intermediaries, like Vortic and Art Gate VR. Unlike the aforementioned types of stores, these do not engage in direct product sales (0 research applications and 4 commercial applications). Instead, these platforms provide a virtual venue for galleries or companies to exhibit and promote their products to a more extensive audience. For the VR galleries, this not only broadens the scope for artistic exposure, but also integrates an innovative visual setting that enhances viewer interaction with the art, thereby transforming traditional gallery visits into immersive, digital experiences.

Given the prototype nature of the majority of the stores, the commercial applications do not require a virtual shopping basket or cart (13 research apps and 2 commercial apps). This observation indicates that these VR environments are primarily intended for the display and exploration of products, rather than for the completion of transactions directly within the VR space. With the exception of Virtual Saturn, this characteristic demonstrates a discrepancy between the potential functionalities of VR shopping environments as revealed in theoretical studies and their current implementations. Theoretical studies employ a full shopping experience including selection, comparison, and purchase, whereas the current implementations that often lack complete transactional capabilities.

The majority of the market applications encompass more than one room, thereby introducing an additional layer of complexity to the shopping experience (0 research apps and 8 commercial apps). For instance, galleries have adopted separate rooms for different exhibitions while Virtual Saturn offers different environments for product presentation. In contrast, almost all stores examined in the literature review had a single room. The employment of multiple rooms in practical applications may signify an objective to create more comprehensive VR shopping experiences that emulate the complexity of physical retail environments. It would be beneficial for retailers and developers to consider dynamic environment designs when developing VR shopping environments, as this could enhance user immersion and satisfaction.

A close examination of the extant literature as well as a thorough evaluation of the practical applications of VR technology in commercial settings reveals a discernible divergence of focus between these two areas with respect to the implementation of VR shopping. The primary objective of commercial VR applications is to engage the users through the use of immersive advertisements and interactive product showcases. Examples include Dyson Demo VR, Teledomica, and ShopR. These applications are designed to enhance sales by making the shopping experience more engaging and interesting. This approach exploits the immersive potential of VR to create environments that can attract customers. Conversely, research in VR shopping tends to focus more on analyzing user behavior and the impacts of shopping in a virtual environment. Studies frequently employ avatars and social settings to examine the influence of these features on shopping behavior and decision-making processes.

6 Conclusion, limitations, and future research

In conclusion, this paper offers a valuable contribution to the field of VR shopping applications by developing a taxonomy that classifies and categorizes relevant commercial applications. The taxonomy can be utilized by researchers, developers, and retailers to gain insight into the landscape of VR shopping applications and to identify current trends among them. Our systematic literature review yielded key insights, which we then compared them with commercial applications. This comparison revealed both commonalities and differences between theory and practice. Although VR shopping has been extensively researched, the available market applications are limited in scope and can be more accurately described as demonstrations. To date, only virtual art galleries have developed fully functional applications. Therefore, despite the encouraging findings of the research, retail enterprises seem to hesitate to create VR store alongside their websites. This finding suggests the potential for further research.

Moreover, while conducting this study, we encountered certain limitations. First, we limited the literature review to empirical studies, which ensured the objectivity and verifiability of the findings. Conversely, non-empirical literature could facilitate a more profound comprehension of the design of VR shopping environments, which could have led to different initial dimensions and characteristics. Second, we disregarded studies utilizing technologies other than HMDs, thus excluding smartphone-based applications. Third, we were not able to include the full range of VR shopping applications identified in initial searches for literature and commercial applications due to availability or the amount of information available online. However, the taxonomy is designed to be extendable, allowing for the incorporation of new VR shopping applications with ease.

The comparison of theory and practice revealed a number of discrepancies, which provide a basis for future research. Firstly, commercial applications offer a more extensive range of products. While research applications often concentrate on areas such as groceries and fashion, commercial applications additionally encompass cars and art. In light of the fact that there are multiple applications in each category, retailers seem to perceive a high potential for both categories. In contrast, the research foundation for art and car marketing in VR remains limited. Therefore, future research could address research questions through the use of quantitative questionnaires, such as: How does a VR presentation of art/cars influence the users' purchase intention? What factors contribute to the acceptance of virtual art/car sales? Potential frameworks to explore these questions are stimulus-organism-response (Jacoby, 2002) or the UTAUT framework (Venkatesh et al., 2003). The taxonomy also revealed a discrepancy between the sizes of the stores utilized for research and those utilized for commercial applications. While all research stores employ one single room, commercial applications often encompass multiple rooms for the product presentation. They offer a variety of environments for users to explore products in different contexts. This suggests the possibility of a research gap in the exploration of the effects of multiple room setups in VR shopping environments on user engagement and satisfaction. Another avenue for future research could be a comparison of different room setups and contexts on user behavior. The only study that we could identify in our literature review that focuses on the comparison of diverse setups is the one by Wölfel and Reinhardt (2019) who compared product ratings in different contexts. Future research should build on this through examining: How does the complexity of VR shopping settings influence consumer behavior? Which contexts are suitable for which product types? Moreover, our findings indicate that while research applications frequently provide the opportunity to purchase products, e.g., to assess the customers' purchase intentions, commercial applications primarily serve as product demonstrations for marketing reasons without the option to make purchases. This demonstrates that commercial VR stores are not affiliated with the online stores of companies, with the exception of Virtual Saturn. However, reasons why enterprises are reluctant to develop comprehensive VR online stores require further investigation. In the context of augmented reality, Chandra and Kumar (2018) identified four key factors influencing the adoption of AR commerce by firms: technological competence, relative advantage, top-management support, and consumer readiness. Nevertheless, no such research exists within the field of VR. We can only guess that similar factors may also be relevant in the context of VR. We hence propose the following research questions for future investigation, which could be explored through interviews or surveys: What factors influence retailers' intentions to adopt VR stores with actual purchasing options? What is the comparative efficacy of VR marketing in comparison to conventional marketing methods? What strategies might be employed to integrate VR stores into existing retail strategies? Finally, we propose to evaluate the taxonomy by experts in this field, as suggested by Kundisch et al. (2021). An overview of evaluation techniques of taxonomies in the information systems area is proposed in Szopinski et al. (2019).

Author contributions

SE: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Visualization, Writing – original draft, Writing – review and editing. JK: Writing – review and editing. KP: Writing – original draft, Formal Analysis. RZ: Writing – review and editing, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Generative AI was used in the creation of this manuscript. We used the software DeepL Write to improve the language of the manuscript.

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