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Review

How to Promote User Purchase in Metaverse? A Systematic Literature Review on Consumer Behavior Research and Virtual Commerce Application Design

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Abstract: Virtual commerce applies immersive technology such as augmented reality and virtual reality into e-commerce to shift consumer perception from 2D product catalogs to 3D immersive virtual spaces. In virtual commerce, the alignment of application design paradigms and the factors influencing consumer behavior is paramount to promote purchase of products and services. The question of their relation needs to be answered, together with the possible improvement of application design. This paper used a systematic literature review approach to synthesize research on virtual commerce from both application design and consumer behavior research, considering the promotion of purchase in virtual commerce settings. Throughout the review, influential factors to purchase and preeminent design artifacts were identified. Then, the research gaps were discovered by mapping the design artifacts to the influential factors, which can inspire future research opportunities on the synergy of these two research directions. Moreover, the evolution of virtual commerce research along with multiple directions were discussed, including the suggestion of meta-commerce as a future trend.

Keywords: virtual commerce; consumer behavior; application design; immersive technology; metaverse

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1. Introduction

Virtual commerce is the commercial activity conducted in an immersive virtual environment. It is one of the latest developments of e-commerce, the phenomenal business tool in the past two decades powered by technological advances, business innovation, and social adoption [1]. From the technology perspective, virtual commerce consists of e-commerce infrastructures, such as electronic product catalogs [2] and electronic payment [3], and adopts immersive technology to create new environments for commercial activities.

Immersive technology consists of the computer software and hardware that stimulate the five senses of humans (i.e., vision, hearing, touch, smell, and taste) in a simulated environment to create the perception of being there, i.e., the sense of presence [4–7]. It has attracted the attention of both industry and academia. In industry, immersive technology has been widely-adopted in gaming in the forms of augmented reality (AR) and virtual reality (VR). Pokemon Go (https://pokemongolive.com/, accessed on 16 November 2021), an AR-based game launched in 2016, generated total revenue of USD 3.15 billion in four years from user spending, and it was estimated to hit USD 1 billion in 2020 [8]. For VR, it is estimated that the VR gaming market reached USD 7.7 billion 2019 [9]. Beyond gaming, investments in VR/AR technology and content in the areas of healthcare [10], education [11], workforce development [12], and manufacturing [13] were expected in 2020 and 2021. In social science research, immersive technology can impact user experience and performance

in many disciplines [6]. Some empirical studies indicate that an immersive shopping experience can provide both hedonic (e.g., an enjoyable realistic shopping experience) and utility values (e.g., efficient product search) [14,15]. Furthermore, immersive technology offers unique marketing opportunities [16].

To adopt immersive technology in virtual commerce applications, the discoveries in user behavior literatures need to be effectively transformed into the *design artifacts* (broadly defined as a construct, a model, a method, or an instantiation [17]) of application design research and development. Therefore, research on virtual commerce applications concerning the two directions of consumer behavior research and application design can follow the design science guideline proposed in [17]. Consumer behavior research empirically evaluates the consumer behavioral responses (e.g., level of acceptance and purchase intention) impacted by certain design artifacts, while research on application design develops and evaluates design artifacts to engage users and promote user consumption through the patterns discovered from consumer behavior studies.

The majority of primary research on these two directions remain independent, although a few studies have studied VR on both directions of consumer response and application design. For example, the solution proposed in [18] can personalize VR shop design through consumer behavior analysis, and [19] performed a small scale interview to identify key elements in both consumer behaviors and development of virtual retailing environments to promote fashion sale in VR shops. On the other hand, the secondary research in the business discipline has systematically reviewed the impact of immersive technology on consumer responses [20,21]. Furthermore, some reviews have summarized the design considerations of AR/VR for marketing [22,23]. Nevertheless, the business disciplines fail to analyze their discoveries with in-depth knowledge of information and communication technology (ICT). Furthermore, the ICT disciplines lack a holistic view on developing and utilizing design artifacts to effectively address the findings in business and consumer behavior research.

This paper attempts to fill in the gap with a systematic literature review on consumer behaviors and design of virtual commerce applications. Precisely, this paper targets consumer purchase intention as the behavior outcome, because purchase intention is one of the most prominent consumer responses evaluated in existing research [24] and has been observed to be impacted by many factors such as behavioral and emotional engagement [25]. The review focuses on literature from two sources: those empirically studying the impact of immersive technology on consumer purchase behaviors and those studying virtual commerce application design. Specifically, behavior papers explain consumer purchase behaviors by establishing and verifying conceptual models of multiple *constructs* (also referred to as factors, stimuli, or responses in a theoretical model) with empirical methods [26], while design papers build and evaluate design artifacts to satisfy given requirements [17]. The knowledge obtained in this paper can shed light on the design of virtual commerce application for purchase promotion and provide guidance for future e-commerce research. In summary, this research has the following objectives.

1. (Model Identification) From behavior papers, synthesize conceptual models concerning consumer purchase behaviors.
2. (Factor Identification) From each identified model, extract influential factors of purchase that can be improved by design science research.
3. (Mapping Identification) From design papers, identify emergent design artifacts of virtual commerce applications that can promote user purchase, and connect the artifacts with the identified factors.
4. (Design Analysis) Analyze the implications of the identified mappings to virtual commerce application design.
5. (Gap Analysis) Based on the factors, artifacts, and mappings, analyze any research gap observed.

The remainder of this paper is organized as followed: Section 2 introduces related work on immersive technology, virtual commerce, and the consumer purchase model;

Section 3 describes the research method of this review; Section 4 presents the review results; and Section 5 concludes this paper with a summary of the findings, contributions, and discussions.

2. Background

2.1. Immersive Technology

Immersive technology describes the technologies that simulate visual, auditory, haptic, and motion realness [6] alone the Reality–Virtuality continuum [27], which has evolved into diverse taxonomies, such as mediated reality [28], the visuo-haptic reality–virtuality continuum [29], and the EPI cube (EPI stands for technological embodiment, psychological presence, and behavioral interactivity) [21], to describe constantly emerging multisensory technologies. In this continuum, VR is well-accepted as a completely synthesized virtual environment [6,21], but the definitions of AR and MR are not settled. For example, [30] identified six MR definitions from the literature review and expert interviews: part of the Reality–Virtuality continuum, a synonym of AR, enhanced AR, a mixture of AR and VR, AR–VR remote collaboration, and physical–virtual environments alignment. Generally speaking, these definitions regard AR as either a subset, a component, or an equivalent of MR. Specifically, AR can display computer generated content (e.g., user interfaces and images) on real world scenes in real time [31], while MR can render virtual scenes, combine virtual scenes with real ones, or provide more complex interactivity, i.e., MR achieves a dynamic coexistence of virtual and real content in the same space. Furthermore, some researchers recently proposed extended reality (XR) to encompass AR, MR, and VR [32,33]. Nevertheless, as XR is only an umbrella concept without distinct features, it is not analyzed in this paper.

AR/MR/VR can achieve either high immersion by displaying the content on special devices such as head-mounted devices (HMDs) and cave automatic virtual environments (CAVEs) [34,35], or low immersion with common displays of computers, smartphones, and so on. For user control, ordinary input devices such as keyboards, mice, and touch screens are sufficient for navigation and interaction in AR/MR/ VR applications [36], yet using special devices, such as a steering wheel and pedals for driving simulation, can enhance the immersive experience [6,21].

Moreover, virtual worlds (VWs) are the technologies that enhance the perceived immersion with character realness of the avatars and residents [37]. A VW is usually networked and situated with intelligent agents, allowing its users to freely interact with the virtual objects and intelligent agents, and communicate with each other [37,38]. The definitions of these concepts are summarized in Table 1.

Table 1. Definition of AR, VR, MR, and VW.

Concept	Definition
Augmented reality (AR)	Realtime display of computer-generated content over a real-world scene [31].
Virtual reality (VR)	Computer-simulated, interactive, and immersive virtual environments that isolate the user from the surrounding physical environment [39], using various immersion methods [6].
Mixed reality (MR)	The dynamic coexistence of virtual and real content in the same space [27].
Extended reality (XR)	An umbrella term for AR, VR, and MR [33].
Virtual world (VW)	Synthetic, persistent, immersive, and networked multi-users environments, allowing users represented as avatars to interact with other users and in-world content in (nearly) realtime [38].

Notably, AR, VR, MR, and VW could induce different behaviors of consumers and have different influential mechanisms or effectiveness. Their differences are implicitly reflected in different virtual commerce application, leading to different purchase models. Nevertheless, the four types of immersive technology can be consolidated into the Reality–Virtuality continuum. Thus, an inclusive framework can be constructed to investigate the relation of purchase behaviors and application design from the four types of virtual commerce application, or even other types within the continuum.

2.2. Virtual Commerce

Virtual commerce describes the consumption of products and services promoted by the activities in an immersive virtual environment such as a VW [40,41]. Virtual commerce includes virtual consumption, i.e., the purchase of virtual objects created in VWs with virtual currency [42], or a mix of virtual–real content and payments [2]. Virtual commerce has been studied from multiple disciplines including business management, consumer behaviors, and software engineering. For example, [43] discussed virtual commerce from a business operation perspective using Second Life (https://secondlife.com/, accessed on 16 November 2021) as a study case, and identified critical factors for the success of virtual commerce systems regarding businesses, VW operators, and the external environment. In terms of consumer behaviors, the affordances of VWs were believed to benefit multiple consumer responses, such as brand attitudes [40], shopping enjoyment [44], and trust [45]. Furthermore, the requirements of VWs for commercial application were studied [46].

A virtual commerce application is an ICT artifact for commercial activities such as retailing and marketing, with MR providing the immersive virtual environments that contributes to numerous improvements over existing e-commerce. For example, using low-immersion VR such as virtual try on (VTO) systems [47], product presentation in retailing is more realistic and interactive compared to the text and images presentations in web-based e-commerce. High immersion VR was perceived to bring a real-world shopping experience into e-commerce and was applied to shopping, marketing, consumer behavior research, and so on [18,48,49]. Meanwhile, AR can present products in the context of a user's surrounding environment to enhance product experience [50].

Recently, transitions from existing e-commerce to virtual commerce retailing have emerged to harvest the benefits of an immersive and enjoyable shopping experience. Alibaba demonstrated VR shopping in 2016 (https://www.alizila.com/11-11-this-year-will-be-most-interactive-ever, accessed on 16 November 2021), and IKEA also deployed VR shops in three countries in 2017 (https://takeleap.com/services/virtual-reality/ikea-virtual-reality-store/, accessed on 16 November 2021). Nevertheless, multiple obstacles should be overcome to realize the full potential of virtual commerce, including but not limited to consumer acceptance, business adoption, and information systems infrastructure and tools [7,51,52].

2.3. Consumer Purchase Model

Although a detailed discussion of consumer behavior research is beyond the scope of this paper, a solid understanding of this discipline, especially on individual purchase behavior, can be beneficial to the systematic review process. Generally speaking, consumer purchase decisions can be described by the five-stage classical model (see Figure 1), which serves well as a theoretical foundation despite having been refined over time [53] and has been adopted in the information system discipline to study consumer behaviors in e-commerce [54].

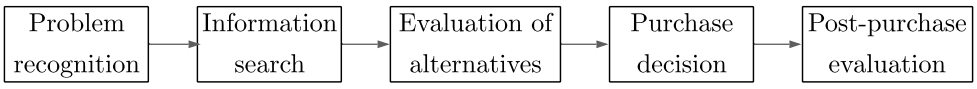

Figure 1. The classical model of consumer purchase decision making.

Among the five stages, the purchase decision stage refers to a consumer's willingness to fulfill a purchase [55], thus, it is perceived as the most relevant factor to the actual

purchase [56,57]. Mostly, purchase decision is measured by purchase intention, i.e., the strength of consumer's willingness to buy a particular product, service, or products and services from a particular brand [58–60]. Furthermore, a purchase decision can be impacted by the activities and factors of all the stages, as a consumer may not strictly follow their sequential orders during a purchase [53].

Moreover, the classical model can be inspected from the view of the stimulus–organism–response (SOR) model [61]. The SOR view has been widely adopted in the research on consumer behavior. In social commerce, the classical model was regarded as the response [54]. Ref. [62] applied SOR to study the effect of authentic experience (stimulus) on the evaluation of VR tourism promotion (response) through cognitive and affective responses (organism). In terms of purchase-related research, [63] studied how unusual purchase (response) was caused by online information exposure (stimulus) during the early stage of the COVID-19 pandemic, while [64–66] studied various components of the stimulus and the organism that caused impulse buying behaviors. Moreover, a stimulus-response model was adopted in marketing research, creating the so-called "buyer's black box" model [67], in which the marketing mix [68] and the marketing environment [69] was regarded as stimuli, the classical model, together with buyer characteristics, was merged into the "buyer's black box", and buyer's responses were measures of the purchase decision process (see Table 2).

Table 2. The black box model in marketing.

Environmental Factors		Buyer's Black Box		Buyer's Responses
Marketing Stimuli	**Environmental Stimuli**	**Buyer's Characteristics**	**Decision Process**	
Product	Economic	Attitudes	Problem recognition	Product
Price	Technical	Motivation	Information search	Brand
Place	Political	Perceptions	Evaluation of alternatives	Dealer
Promotion	Cultural	Personality	Purchase decision	Purchase amount
		Lifestyle	Post-purchase evaluation	Purchase timing

Based on the classical model of consumer decision making and the SOR model, a holistic view of individual consumer purchase in virtual commerce can be established. Purchase decisions can be regarded as the response, and the characteristics of virtual commerce belonging to either immersive technologies or consumer behaviors can be captured as stimulus or organism.

3. Methodology

This research adopted a systematic literature review approach to address the objectives mentioned in Section 1. Systematic literature review is a rigorous approach to identify, evaluate, and interpret available literature relevant to the research topic of interest, in order to synthesize observations and identify research gaps. This approach has been applied to study multiple emerging topics in information system research, including the application of VR/AR in tourism [70], big data analytics in e-commerce [71], and social commerce [72]. This paper followed the guideline in [73], which summarized systematic review as three phases: planning, conducting, and reporting the review. Based on [73], this review consists of the following processes: (1) identify the need for review, (2) specify the research questions, (3) develop review protocol, (4) identify and select papers, (5) assess paper qualities, (6) extract and synthesize data.

The need for review has been addressed in Section 1. As for research questions, four questions are proposed based on the objectives in Section 1, which are:

1. How are consumer purchase behaviors conceptualized in virtual commerce?
2. What are the influential factors of purchase that can guide application design?
3. How can application designs promote purchase in virtual commerce?
4. What are the implications for virtual commerce application design?
5. What are the research gaps?

To gather relevant papers, the initial search was conducted on eight online databases: EBSCO, Proquest, ScienceDirect, Scopus, SpringerLink, Web of Science, Emerald, and Wiley, which are believed to be relevant and cover papers from multiple disciplines. An impact factor threshold to limit the source of the papers was not considered to avoid sampling bias [74]. The keywords of "virtual world", "virtual reality", "virtual environment", "mixed reality", or "augmented reality" were used to represent immersive technologies, while the keyword "commerce" was used to limit the application domain. The combination of these keywords was applied to the title, abstract, and keyword fields. Since the available search conditions and search syntax of each database is different, we adopted the search terms for each database, as shown in Table 3. The search results were collected from July 2021 to September 2021.

Table 3. Search terms for selected databases.

Database	Search Term
EBSCO	Title or Abstract contains: virtual and commerce and (world or reality or augment or mixed or environment)
Proquest	ti(commerce) AND ab(commerce) AND ab((virtual AND (realit* OR environment OR world*)) OR ((mix* OR augment*) AND reality)) AND ti((virtual AND (realit* OR environment OR world*)) OR ((mix* OR augment*) AND reality))
ScienceDirect	title, abstract, keywords: commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality))
Scopus	TITLE(commerce AND ((virtual AND (realit* OR environment OR world)) OR ((mix* OR augment*) AND realit*))) AND ABS(commerce AND ((virtual AND (realit* OR environment OR world)) OR
SpringerLink	commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality))
Web of Science	(TI = (commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality))) AND AB = (commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality))) AND (AK = (commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality))) OR KP = (commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality)))))) AND LANGUAGE: (English)
Emerald	(content-type:article) AND (title: "commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality)))" AND (abstract: "commerce AND ((virtual AND (reality OR environment OR world)) OR ((mix OR augment) AND reality)))"))
Wiley	"commerce AND ((virtual AND (realit* OR environment OR world)) OR ((mix* OR augment*) AND realit*))" in Title and "commerce AND ((virtual AND (realit* OR environment OR world)) OR ((mix* OR augment*) AND realit*))" in Keywords and "commerce AND ((virtual AND (realit* OR environment OR world)) OR ((mix* OR augment*) AND realit*))" in Abstract

Search results from the initial search were aggregated to remove duplicates. Then, the remaining papers were examined against the inclusion and exclusion criteria on the abstract, introduction, and conclusion sections. Next, full-text screening was applied to the remaining papers against the eligibility criteria. During the full-text screening, references from each paper were manually examined against the aforementioned criteria. The remaining papers from the database search and additional papers from the references search were examined again over the research questions. In this step, information was

extracted and encoded with Microsoft Visio and Excel. The extracted information was iteratively reviewed and examined by all researchers and recoded if necessary.

The inclusion/exclusion criteria guaranteed that search results are accessible and relevant, while the eligibility criteria guaranteed the research value of the search results to virtual commerce. Particularly, the search results should be relevant to virtual commerce, i.e., the topics studied should contribute to either virtual commerce application design or consumer behavior mediated by immersive technology. Moreover, if an extended version of a search result was found (e.g., a conference version was extended to a journal version), only the most extended version was included. The eligibility criteria ensured that all included results can contribute to at least one of the four research questions. Furthermore, papers that failed to elaborate on the whole research process were not considered. Specifically, for behavior papers, rigorous empirical studies are required, while for design papers, the designed artifacts and the design process should be presented. In addition, the relatedness criteria ensured that all included results can contribute to at least one of the four research questions.

Figure 2 summarizes the search process, with the number of remaining papers attached to each step. The initial database search returned 306 papers. Duplicate removal and scanning of abstract, introduction, and conclusion left 60 papers for full-text analysis, which excluded 1 paper unrelated to virtual commerce. The 59 remaining papers and 58 additional papers identified from the reference search were examined again with the relatedness criteria, which kept 68 papers for data extraction and synthesis.

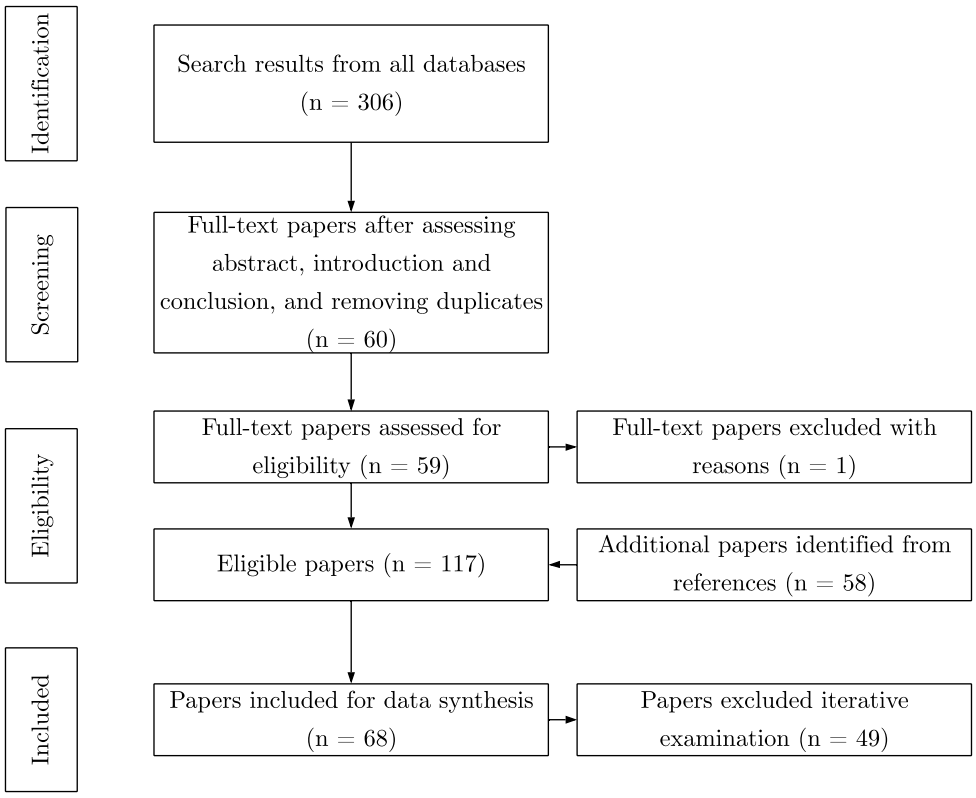

Figure 2. Summary of the search process.

The following are the inclusion, exclusion, and eligibility criteria for each paper.

1. Inclusion criteria:
   - A full-text version of the paper is available.
   - The paper is related to virtual commerce.
   - The paper is written in English.
2. Exclusion criteria:

- A full-text version of the paper is not available.
- The paper is not related to virtual commerce.
- The paper is not written in English.
- An extended version of the paper is available.

3. Eligibility criteria:
   - Be an original research paper published in an academic journal or conference.
   - Be a complete research paper, presenting the research issue, process, and results.
   - Address a research topic related to virtual commerce.
4. Relatedness criteria:
   - Answer question Q1 and either Q2 and Q3 or Q4 or Q5 .

4. Findings and Discussion

In this section, the research questions Q1–Q5 are answered in Sections 4.1–4.5 correspondingly. Specifically, the first two questions targeted the behavior papers to obtain the fundamental factors during the consumer purchase decision-making that lead to a purchase decision. The first question aimed to construct a holistic view of consumer purchase in virtual commerce by unifying the theories applied in each behavior paper. Subsequently, the second question further inspected the unified theories in Q1 to determine the fundamental factors. The last three questions targeted both design and behavior papers. The third question established a connection between design research and the influential factors in Q2 to identify how improvement on application design can promote purchase in virtual commerce through these factors. The fourth question addressed the higher-level application design topics leveraging the findings in Q3. Finally, the fifth question inspected the findings of the first three questions to discover challenging research issues and future research directions.

4.1. Conceptual Framework of Purchase in Virtual Commerce

The conceptual framework of user purchase in virtual commerce should be related to the general consumer purchase decision-making model (Figure 1) as a subclass with refined constructs and the same outcomes (i.e., purchase decision). Logically, it should either contain the purchase decision construct or a closely related factor in the consumer purchase decision-making model, and should reflect a consumer's cognitive or affective characteristics. Specifically, the conceptual framework is induced from the models in the reviewed papers with the following procedure.

Step 1. From a conceptual model in a reviewed paper, look for the purchase decision construct or the post-purchase evaluation construct, or a construct closely and positively related to purchase decision or post-purchase evaluation, as a final outcome.
Step 2. Identify all the positive constructs leading/related to the final outcome.
Step 3. Record these constructs and their relations.
Step 4. Infer and integrate all the identified models leading to the same final outcome to construct the unified conceptual framework .
Step 5. Reduce the constructs to those that reflect the stimulus or organism in the SOR view of consumer behavior (in Table 2).

To consistently present the findings, the conventions to describe construct types and relations were listed in Tables 4 and 5, respectively. Any following model can be described by three types of construct and three types of their relations. Specifically, a model was initiated with one or multiple primitive constructs, passed through intermediate constructs, and converged to a final outcome along paths of causality relation. A primitive construct can also contain multiple facets with an inclusion relation. Moreover, the strength of a relation can be moderated by a consumer's emotional state, such as the "endowment effect" in Figure 3.

Table 4. Definitions of construct types.

Construct	Definition
Primitive construct	Used only as source or component in relation to other constructs.
Intermediate construct	Serves as outcome in relation to a primitive construct, as either source or outcome in relation to other intermediate constructs, or as source in relation to final outcome.
Final outcome	Used only as outcome in relation to other constructs.

Table 5. Definitions of relation types.

Relation	Definition
Causality/Mediation	The outcome is expected when the source exists or the outcome is mediated by the source. Represented as a single arrow connector, with the arrow pointing to the outcome.
Inclusion	The source can be regarded as a facet of the outcome. Represented as a dash-dot-line connector, with the arrow pointing to the source.
Moderation	The source modifies the strength of a causal relation. Represented as a dash-line connector, with the arrow pointing to the causal/mediation relation.

Overall, purchase decision in the user purchase decision model was represented by purchase intention in reviewed papers. Although a purchase decision does not necessarily lead to an actual purchase [55], it is the most appropriate estimator of actual behavior [56,57]. Therefore, it is valid to treat purchase intention as the final outcome of a conceptual model. Eight consumer outcomes directly related to purchase intention were discovered and are summarized in Table 6 . Their relations are presented in Figure 3. Here, the relation of each consumer outcome to purchase intention is summarized independently. The relation between these outcomes, such as the mediation from enjoyment to customer satisfaction, is outside the scope of this paper and will be studied in future.

Table 6. Final outcomes to purchase intention.

Outcome	Abbreviation	Description
Attitudes toward technology (AT)	AT	Consumers' feeling toward the innovativeness of immersive technology.
Brand attitude	BA	Consumers' feeling toward the products and services of a brand.
Endowment effect	Nil	The bias of a consumer's evaluation of owned products.
Enjoyment experience	EE	The joy of shopping stimulated by immersive technology.
Product attitude	PA	Consumers' evaluation of products presented with immersive technology.
Trust	Nil	Consumers' willingness to further interact with a virtual shopping environment.
User satisfaction	US	Consumers' evaluation of a virtual shopping environment on satisfying their needs.
Utilitarian value of product	UV	The perceived usefulness of a product.

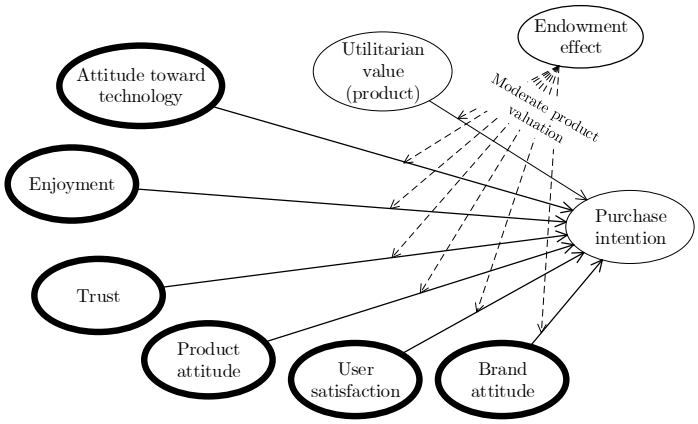

Figure 3. The unified conceptual framework of consumers' purchase intention in virtual commerce.

User satisfaction (US) was studied in six papers [75–80]. All empirical studies in these papers were conducted in VR/VW. In a virtual store setting, enjoyment, engagement [75], and consumer's perceived quality assurance [76] were identified as direct factors affecting user satisfaction. Ease of use, as an aspect of perceived quality assurance [76], was believed to influence enjoyment [79]. In addition, ref. [78] studied the effect of store layout and confirm its influence on consumer's enjoyment and ease of navigation. Furthermore, ref. [80] built a virtual furniture retailing store and studied the pleasure and arousal factors on user satisfaction, purchase intention, and decision confidence, which echoed the effect of hedonic value and user engagement in [75]. Ref. [77] also studied the relation of user satisfaction with consumer trust, store informativeness, product diagnosticity, and product description, though no significant differences have been found between 2D web sites and 3D virtual stores. Figure 4 summarized the aggregated relations of user satisfaction with virtual reality shopping sites.

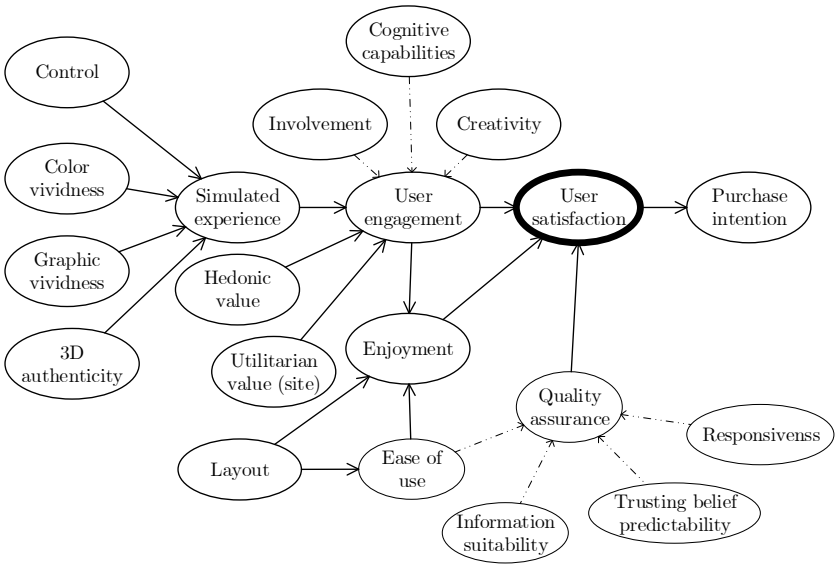

Figure 4. Conceptual framework of user satisfaction with a VR shopping site.

The user's trust in the virtual shopping environment was studied in [81,82]. Here, the trust outcome refers to the psychological status of consumers who are willing to further interact with the shopping environment to achieve a planned goal. Ref. [81] studied the relation of shopping attitudes and consumer trust cultivated during shopping, which was claimed to be dually influenced by perceived telepresence and social presence, while [82] studied the constructs of these two outcomes. Merging the results of these two papers produced the model of user trust in Figure 5.

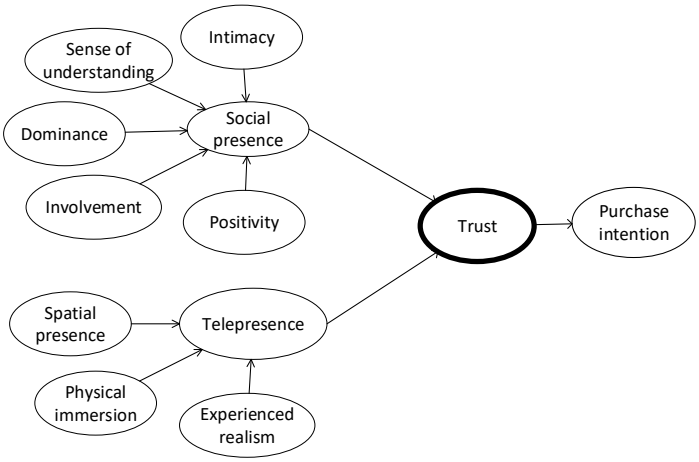

Figure 5. Conceptual framework of consumer trust of the VR shopping site.

The consumer's enjoyment experience (EE) was studied in four papers [81,83–85], and all of them used VR/VW to create the virtual shopping environments. Using a means-end analysis to study the affordances of VWs, ref. [83] discovered that the enjoyment experience was motivated by discovering new products and interaction with people, which were facilitated by 3D environments and multi-user environments, respectively. Ref. [81] found that telepresence and perceived social presence also contributed to a consumer's enjoyment, where telepresence was the level at which the user feels present in the mediated environment and perceived social presence was the psychological perception of others' presence as facilitated by a communication medium [40,41]. Ref. [84] discussed that decorative activity and role-playing in social VWs supported the goal of amusement for virtual consumption. Judging from the paper, decorative activity expressed the sense of presence in the social VW, while role-playing can be regarded as social presence. Ref. [85] also supported that enjoyment experience in a Stereo VR shop can enhance purchase intention through product interactions and immersion in the stereoscopic environment, echoing the findings in [81]. Based on these findings, the constructs and relations concerning user enjoyment experience were extracted and shown in Figure 6.

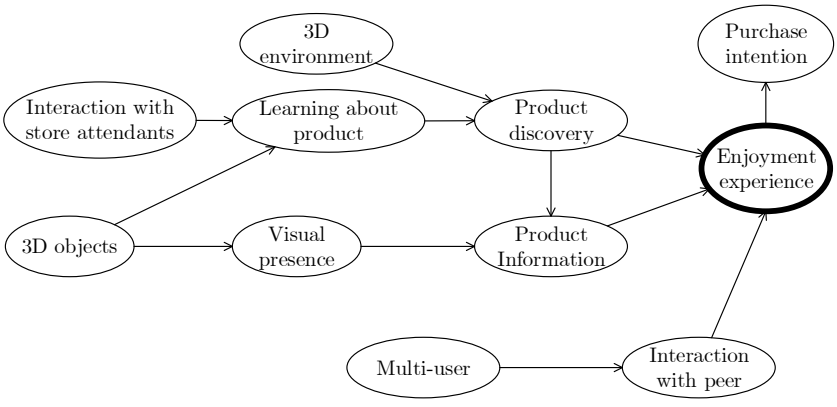

Figure 6. Conceptual framework of a consumer's enjoyment experience created during shopping.

Product attitudes (PA) were discussed in six papers [50,86–90]. Ref. [86] studied the relation of modality richness and consumer attitudes toward a product mediated by the level of consumer involvement. Modality richness refers to the sensory (e.g., visual and audio) and contextual information sources that a multimedia format provides [90,91], which can be reified to the 3D quality of simulations in the context of virtual commerce according to [88]. Ref. [87] found that consumer's product attitudes were also influenced by consumer's cognitive elaboration, which was mediated by object interactivity and moderated by the consumer's goal to product search or browse. In addition, ref. [50] found

that using virtual fitting rooms as sale aids on a website can increase purchase intention by affecting product curiosity and patronage intention. In [89], product attitudes, represented by the constructs of perceived food quality and perceived value price, were enhanced by telepresence and consumer evocativeness that stimulated consumers' experience of the products with which they were interacting. These findings were aggregated and illustrated in Figure 7.

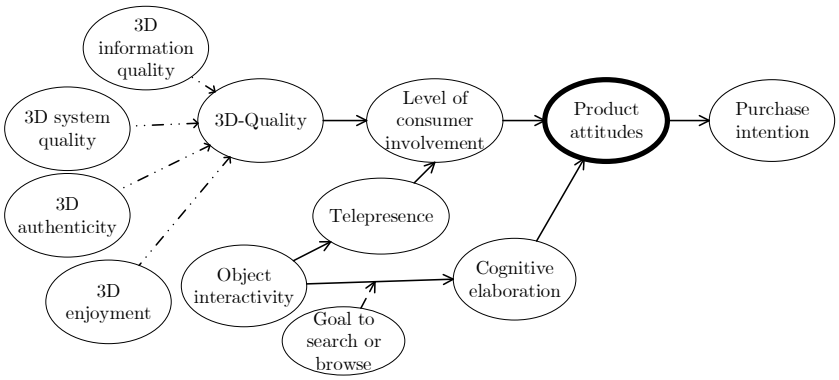

Figure 7. Conceptual framework of a consumer's product attitudes.

Attitudes toward innovative technology (AT) were studied in four papers [92–95], three of which focused on attitudes toward AR. The effectiveness of AR on purchase intention was evaluated in [92,93] through comparison to conventional online e-commerce sites. Ref. [92] studied consumer's attitudes toward AR from the perspective of enjoyment experience generated from AR's immersion effect. Ref. [93] studied a similar issue using an extended technology acceptance model (TAM) to investigate the factors influencing a consumer's perceived usefulness of AR, the result of which not only confirmed the role of perceived enjoyment in [92] but also discovered that perceived informativeness, i.e., the extent to which users feel the product information is relevant and useful, influenced AR attitudes through the perceived usefulness of AR. Ref. [94] applied TAM to study AR-based mobile Virtual Try-on, the result of which was similar to [93]. Finally, ref. [95] studied consumer adoption of Virtual Try-on, which was an innovative tool back then. These results were summarized as consumer's attitudes toward innovative technology and depicted in Figure 8.

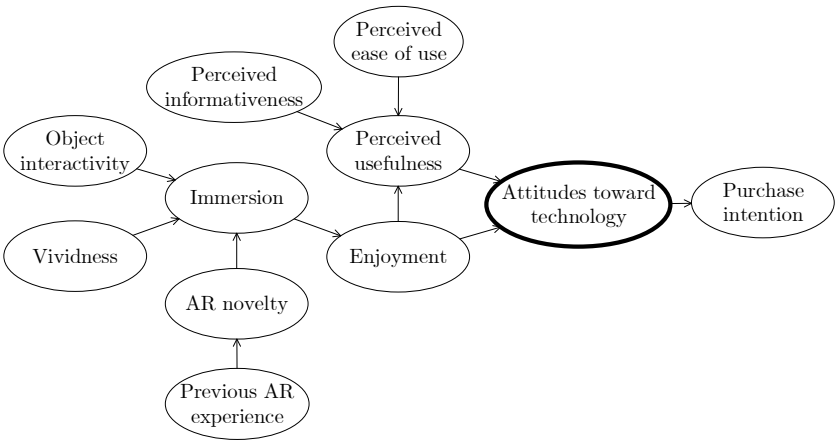

Figure 8. Conceptual framework of a consumer's attitudes toward innovative technology.

Branding, as an important marketing activity in virtual commerce for nurturing consumer's purchase intention, was studied in seven papers [16,40,49,96–99]. Ref. [96] qualitatively studied the affordances of VWs that enhanced brand equity [100,101] by creating flow, a mental state of engagement, and enjoyment of an activity [102,103]. The re-

sult from [49] revealed that sense of presence and brand recall contributed to purchase intention in VR shopping. Ref. [97] established a framework relating the affordances of the virtual shopping environment to a consumer's flow state, and subsequently relating it to a consumer's brand recall and return visit rate, while virtual agent was also identified to be important to a consumer's flow state. Ref. [98] investigated the relation of consumer's brand attitudes (BA) with virtual experience, a similar psychological and emotional state to flow, generated during the interaction with 3D visual products. Ref. [99] studied flow in the context of virtual consumption and showed the influence of interactivity, vividness, and involvement on a consumer's willingness to purchase through flow, where interactivity and vividness were related to the technical aspect of a VW, while involvement was related to the social aspect. Similarly, ref. [40] also claimed that physical presence in a 3D VW, i.e., the perception of the virtual environment as a real one, can positively affect a consumer's connection with a brand. Ref. [16] also studied brand engagement by using AR in private space and found the importance of AR interactivity in this setting. To summarize, Figure 9 shows the aggregated conceptual model of a user's brand attitudes.

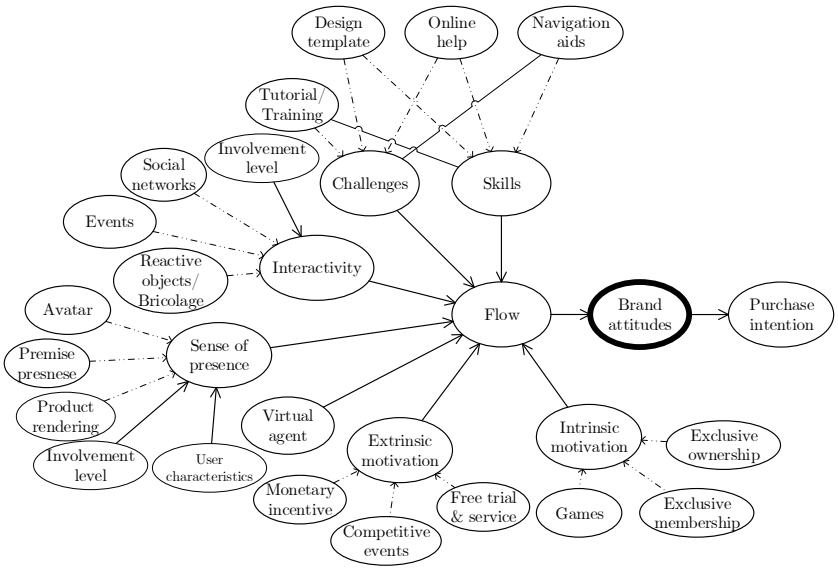

Figure 9. Conceptual framework of a consumer's brand attitudes.

In addition to the aforementioned six constructs and the corresponding relations, the utilitarian value of a product (UV) was also identified to mediate purchase intention [84,104], while [105] found that endowment effect can moderate consumer's valuation of a product, which was influenced by the user interface and object interactivity design. In addition, findings in some papers were merged into multiple models. For example, ref. [106] studied the relation of consumer involvement level to multiple consumer outcomes, including user satisfaction and brand loyalty. Ref. [41] claimed that purchase intention of virtual goods in a social VW was positively influenced by flow, which was impacted by telepresence and social presence.

4.2. Influential Factors Essential to Virtual Commerce Design

In a conceptual model, the sequence from primitive constructs to a final outcome followed an ascending level of abstraction. Observing the models from Figures 4–9, the primitive constructs were mostly stimuli external to a consumer's perception or surface perceptions that triggered more complicated perceptions represented as intermediate constructs. Primitive constructs were not only the root causes of a final outcome in a conceptual model but also more concrete references to application design compared to intermediate constructs. On the other hand, intermediate constructs were only complicated perceptions triggered by primitive constructs, similar to the mediation variables in an empirical study. Thus, primitive constructs were essential to virtual commerce design.

Yet, not all of them are related to virtual commerce design, e.g., extrinsic motivation in the model of a consumer's brand attitudes (Figure 9). A concretization–signification–categorization strategy was proposed as follows to identify all influential factors from distributed and application design-related primitive constructs, which are called boundary factors (summarized in Table 7).

Table 7. List of boundary factors and corresponding included papers.

Boundary Factor	Description	Reference(s)	Related Immersive Technology	Impacted Final Outcome(s)
3D authenticity	The extent to which online sensory information approximates the real world stimulus, generated from control, color vividness, and graphic vividness.	[75]	VR, VW	PA, US
3D authenticity	The extent to which online sensory information approximates the real world stimulus, generated from control, color vividness, and graphic vividness.	[75]	VR, VW	PA, US
3D information quality (or perceived informativeness)	The extent to which 3D models provide accurate, relevant, complete, and precise information regarding the presented products, reflecting the content and form of the presented product, which users look for.	[76,88,93–95]	AR, VR, VW	AT, EE, PA, US
Control	The ability to control the relationship of one's senses to the stimulus, i.e., the ability to modify the stimulus.	[75]	VR	US
Ease of use (or challenge, skill)	The degree to which a person believes that using a particular system would be free from effort.	[76,79,81,82,93–96]	AR, VR, VW	AT, BA, US
Experienced realism	The degree of familiarity in virtual online shopping, which is relative to an authentic off-line shopping experience.	[82]	VR	EE, Trust
Hedonic value (enjoyment, positivity)	Concerns the emotional state emerging from the experience and may include all elements that cause a state of pleasure, such as color, graphics, animation, and other design elements.	[75,76,79,88,93–95]	AR, VR, VW	AT, Trust, US
Layout (3D environment)	The material, look and feel, or architectural design artifact applied in a 3D online shopping environment.	[78]	VR, VW	EE, PD, US
Object interactivity	The ability of a user to directly manipulate an object within a virtual environment, measured by speed (i.e., responsiveness), mapping (i.e., realism), and range (i.e., dimension).	[16,41,85,92,96,97,105,107]	AR, VR, VW	AT, PA
Social presence	The shopping site conveys a feeling of human contact, sociability, and sensitivity in the attempt to approximate the in-store consumer experience.	[41,81,82]	VW	EE, Trust

Table 7. *Cont.*

Boundary Factor	Description	Reference(s)	Related Immersive Technology	Impacted Final Outcome(s)
Spatial presence	User's sense of being there, feeling transported to another environment, component of telepresence.	[40,49,82,85]	VR, VW	EE, Trust
Trusting belief predictability	The willingness of a customer to be vulnerable to the actions of a seller based on the expectation that the seller will perform a particular action important to the customer.	[76]	VR	Trust, US
Usability (usefulness, utilitarian value)	The extent to which a system, product, or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.	[75,81,82,92–95,104]	AR, VR, VW	AT, US, UV
User engagement (physical immersion)	Consists of a psychological state including involvement and effective usage of cognitive capabilities, as well as creativity, classified into two different levels: low and high.	[81,82]	VW	BA, PA, Trust, US
Virtual agent	Represent a seller in a virtual environment to provide a customer service experience closer to the physical one, which helps to create an atmosphere of trust.	[97]	VW	BA
Vividness (color vividness, graphic vividness, modality richness)	Refers to the quality of product presentations to sensorially enrich consumers' experience in depth and/or breadth in e-commerce.	[92,96,107,108]	AR, VW	EE, PA, US

1. **Concretization.** Primitive constructs in the models from Figures 4–9 were first inspected and those that were deemed subjective by all researchers, i.e., capturing the cumulated events and preferences of an individual, were excluded since they cannot be enhanced via technical improvement.
2. **Signification.** From the remaining constructs in Step 1, multiple constructs were merged as one if they shared a common connotation. To exemplify, perceived informativeness in the consumer's attitudes toward innovative technologies model was similar to 3D information quality in the consumer's product attitudes model: both characterized the extent to which 3D models provide accurate, relevant, complete, and precise information regarding the presented products. Thus, they were considered as one boundary factor.
3. **Categorization.** Multiple primitive constructs were categorized into a boundary factor if it can include their senses, simplifying the mapping process to application design. As an example, intimacy, sense of understanding, dominance, involvement, and positivity can be categorized into the boundary factor of social presence.

4.3. Promoting Purchase through Application Design

To promote purchase, the application design research should seek to improve the boundary factors identified in Section 4.2, as they characterize the fundamental effects of immersive technologies on consumer purchase in virtual commerce. In fact, as summarized in Table 8 , virtual commerce application design can be perceived as an aggregation of multiple low-level design artifacts which, as discussed below, can be mapped to the boundary factors, and thus associated application design with purchase behavior research.

Table 8. Design artifacts of virtual commerce systems.

Category	Design Artifact	Definition	Reference(s)	Related Immersive Technology
AR	Direct product information presentation	In AR applications, display product information at appropriate positions of the graphical user interface.	[109–114]	AR
	Fashionable facial accessories try-on	In AR applications, use algorithms to track the position and movements of a human face to accurately display virtual facial accessories.	[113,115,116]	
	Feature matching accuracy improvement	In AR applications, improve the accuracy of virtual object positioning.	[112]	
	Marker-free	The design of AR applications without using markers for tracking.	[110,111,117–119]	
	Mobile AR	The design of mobile platform AR applications.	[109,115,118,119]	
	Stand-alone AR	AR technologies that integrate tracking, displays, calculation, and other AR-related tasks in a single device.	[110,111,118,119]	
Client design	3D representation of a multi-agent system	The design of 3D VWs populated by agents that are either autonomous or human-controlled.	[120–122]	VW
	Accessibility	The use of standard protocols, software, procedures, and so on to deliver the designed artifact to a broad audience.	[123–125]	AR, VR, VW
	Combining virtual environment and Sociality	The design of a 3D virtual shopping mall for collaborative shopping.	[121]	VR
	Intuitive virtual shop interface	The design of the user interface that provides natural interaction with the virtual objects.	[123,126,127]	AR, VR, VW
	Scalability	The capability of an application to handle large-scale concurrent access to its services.	[46,124]	VW
	Social commerce system design framework	The design principles and practices that consider multi-user activities.	[46,128]	VW
	Virtual mall	An integrated solution to 3D virtual mall creation, operation, and navigation.	[129]	VW
	VR Shopping experience enhancement	Design principles and practices that generate an enjoyable shopping experience in a VR shop.	[130,131]	VR
Customization	Product customization	The capability to dynamically display products based on a user's characteristics and inputs.	[117,118,132]	AR, VR
	Product searchability and recommendation	The capability to accurately provide or recommend products based on user inputs or activities.	[121,127,130,133–136]	AR, MR, VR
	User-designed virtual environments for product visualization	A framework that allows customers to personalize a 3D virtual room and certain properties of the pre-defined products.	[137]	VR
	Virtual shop personalization, customization, or consumer adaption	Dynamic generation of 3D virtual shop based on a user's characteristics and preferences.	[18,46,138–141]	VR, VW
Software agent	Navigation agent	The design of software agents for navigation in 3D virtual environment.	[140]	VR
	Sales agent for price negotiation	Software agents that users can interact with to negotiate price.	[46]	VW
	Semantic agent for information query	The use of semantic technologies to develop virtual retailing environments that support information query.	[142]	VW
	VR-driven shopping agent for decision support	A combination of VR avatars and decision support system for VR shopping.	[135]	VR
Function design	Navigability	The design of functions to navigate the users to a specific product in a 3D virtual environment.	[119,129,138,139]	AR, VR
	Realistic product modeling	Methods to render a product such that it is perceived to be real by users.	[133]	VR
	Reputation mechanism	A method to objectively evaluate a seller's reputation based on user reviews using VR.	[143]	VR, VW
	Trust-building interaction design	The design principles and practices of a VR-based e-commerce environment using an empirically-tested trust-building model.	[136]	VR, VW

The design artifacts in each design paper were identified either from explicit statements in the paper, which mostly occurred in the abstract, introduction, or conclusion sections, as was observed during the review process, or from the inference of all researchers on the description, performance, or evaluation of the proposed work. Table 8 summarized

all identified design artifacts and related design papers. Similarly, mapping design artifacts to boundary factors depended on either clear arguments in the design papers or judgments by all researchers. Table 9 aggregated Tables 7 and 8 to present the mappings of design artifacts and boundary factors.

From Table 9, it can be observed that most designs addressed consumer's perceived ease of use, which was mapped to 14 of the 26 identified design artifacts, most of which are AR-related, either providing mobility, marker-free, standalone, and hand-free AR solutions, or pushing the evolutions of AR for the use of e-commerce with innovations in various tracking and matching algorithms. Apart from AR, design artifacts focusing on virtual shops can also contribute to ease of use, for example, intuitive shopping interfaces for object interaction, navigation aids in virtual shops, and personalized shopping experience. The use of software agents for navigation in virtual shops or decision support and client accessibility improvement based on standard software can also reduce a consumer's effort in online shopping.

The second most covered boundary factor was usability, addressed in eight design artifacts, and six of them also covered ease of use. Several of these design techniques were product-oriented, such as locating the position of a retailer or a product within a large and complex 3D environment and and searching for or recommending products. In addition to ease of use, usability was mostly considered with various factors in other designs. For example, virtual store design guidelines can enhance user engagement and provide experience realism to consumers. The VR shopping experience can be improved by a multi-kinect approach for motion tracking to provide natural movement in the VR environment. Product customization solutions can provide consumers the control of product visual presentation through manipulating product features. Dynamic product update, which was mapped to usability only, allowed retailers to update available product models as requested in product presentation and facilitated consumers to achieve their shopping goals.

Table 9. Mapping of design artifacts and boundary factors.

Design Artifact Category	Design Artifact	Related Influential Factor(s)	Impacted Final Outcome(s)
AR	Direct product information presentation	3D information quality	AT, EE, PA, US
	Fashionable facial accessories try-on	Ease of use, User engagement	AT, BA, PA, Trust, US
	Feature matching accuracy improvement	Ease of use	AT, BA, US
	Marker-free	Ease of use	AT, BA, US
	Mobile AR	Ease of use	AT, BA, US
	Stand-alone AR	Ease of use	AT, BA, US
Client design	3D representation of a multi-agent system	Social presence, Virtual agent	BA, EE, Trust
	Accessibility	Ease of use	AT, BA, US
	Combining virtual environment and Sociality	Experienced realism, Social presence	BA, EE, Trust
	Intuitive virtual shop interface	Ease of use, Experienced realism	AT, BA, EE, Trust, US
	Scalability	Social presence	EE, Trust
	Social commerce system design framework	Social presence	EE, Trust
	Virtual mall	Layout, Spatial presence	EE, PD, Trust, US
	VR Shopping experience enhancement	Experienced realism, Usability, User engagement	AT, BA, EE, PA, Trust, US, UV
Customization	Product customization	Control, Object interactivity, Usability	AT, PA, US, UV
	Product searchability and recommendation	Ease of use, Usability	AT, BA, US
	User-designed virtual environments for product visualization	Ease of use, Usability	AT, BA, US
	Virtual shop personalization, customization, or consumer adaption	Ease of use, Usability	AT, BA, US

Table 9. *Cont.*

Design Artifact Category	Design Artifact	Related Influential Factor(s)	Impacted Final Outcome(s)
Software agent	Navigation agent	Ease of use, Usefulness, Virtual agent	AT, BA, US
	Sales agent for price negotiation	Virtual agent	BA
	Semantic agent for information query	Ease of use, Usability, Virtual agent	AT, BA, US
	VR-driven shopping agent for decision support	Ease of use, Usability, Virtual agent	AT, BA, US
Function design	Navigability	Ease of use, Usability	AT, BA, US
	Realistic product modeling	3D authenticity, Experienced realism, Vividness	EE, PA, Trust, US
	Reputation mechanism	Trusting belief predictability	Trust, US
	Trust-building interaction design	Trusting belief predictability	Trust, US

Virtual agent was another factor receiving sufficient attention from design papers and was identified in five design artifacts. Virtual agents provided multiple functionalities, ranging from price negotiation, information query, navigation assistance, to decision support. It was also believed to stimulate a sense of sociality.

In addition, five design artifacts (combining virtual environment and sociality, fashionable facial accessories try-on, intuitive virtual shop interface, realistic product modeling, and virtual mall) can augment spatial presence, experienced realism, and user engagement, which were believed to mediate telepresence, as described in Figure 5. Notably, the virtual mall design, which connected multiple separate virtual stores, not only enhanced spatial presence but also provided a continuous shopping layout for a sense of reality and ease of navigation. The consumer's sense of social presence was provoked when a virtual shopping system facilitated multiple users to be co-located and view each other within the same space [121], turning e-commerce into social commerce [128]. Social presence can also be stimulated by improving system scalability, which increased the consumer capacity of a virtual environment. The realistic product modeling technique in [133] not only evoked experienced realism, but also influenced 3D authenticity and vividness, or the consumer's simulated experience, according to Figure 4. Furthermore, telepresence was enhanced by product customization techniques that can increase object interactivity, which can be inferred from Figures 7 and 8.

Moreover, two design artifacts were mapped to the boundary factor of trusting belief predictability. Ref. [143] developed a reputation mechanism through buyers' objective feedback (e.g., five-sense perception) and subjective perceptions (e.g., rating) about products. Ref. [136] proposed a multi-stage agent-based interaction design for trust-building by showing sellers' benevolence, competency, and integrity.

4.4. Implications to Virtual Commerce Application Design

Researchers can leverage the findings summarized in Tables 8 and 9 to establish some generic design guidelines for virtual commerce applications. A guideline can consist of the following steps as a reference.

First, business objectives identification. The high-level objectives can be firstly identified among six dimensions of the influential factors in Figure 3: technology attitude, brand attitude, product attitudes, enjoyment, trust, and user satisfaction. With the high level objectives, more concrete objectives can be derived following the models in Figures 4–9 from the outcomes all the way down to influential factors. This can help narrow the search space for applicable design decisions.

Second, design requirements analysis. The design artifact categories in Table 8 can be mapped to five types of design requirements: forms of immersive technology, interface, performance, intelligence, and function, which are listed in Table 10. Based on this categorization, researchers should analyze the pairwise relations of design requirements and business objectives. This can be achieved by the mappings of impacted final outcomes,

influential factors, and design artifacts categories in Table 9. For example, the goal of user trust can be converted to the interface and function requirements. The interface requirement consists of all design artifacts except for accessibility in the client design category in Table 9, and the function requirement consists of all design artifacts except for navigability in the function design category.

Table 10. Design requirements and related design artifact categories.

Requirement	Description	Related Artifact Category
Forms of immersive technology	The choice of immersive technology for an application, e.g., AR/VR/VW	AR
Interface	Appearance and function of a user interface for different user groups, e.g., client interface for consumer	Client design
Performance	Efficiency of given tasks, e.g., customizing product presentation and the appearance of a virtual shopping environment	Customization
Intelligence	Provision of intelligent tools to automate certain tasks, e.g., software agent for various retailing tasks	Software agent
Function	The special purposes of an application, e.g., reputation enhancing mechanism	Function design

Finally, design pattern determination. A design pattern is a reusable alternative to some design requirements. After determining design requirements, the design artifacts in Tables 8 and 9 can be treated as some useful design patterns. Moreover, their implementations in the corresponding design papers can be referred to in practices.

Through these three steps, the applicable design patterns to the business objectives can be recognized, and the most cost-effective and efficient plan to perform the application design can be determined. To illustrate, consider an application to achieve positive product response, i.e., improvement on the dimension of product attitude. Then, Table 7 suggests that product attitude can be achieved by an authentic, informative, and vivid 3D display. Therefore, forms of immersive technology and function are the most prominent requirements, and by referring to Table 9, the appropriate design patterns can be AR-based realistic product rendering and AR-based information presentation.

In the future, researchers can implement application prototypes for these design patterns, which should be confronted with customers in virtual commerce, to empirically evaluate their effectiveness and obtain first-hand understanding of their priority, importance, implication to the high level design objectives, and so on.

4.5. Research Gaps

We identified the research gaps of virtual commerce research from these perspectives: (1) dominant design artifacts (Table 8) and boundary factors (Table 7) covered in the included papers, (2) characteristics of design-factor mappings (Table 9), (3) promising design artifacts or boundary factors that were ignored, and (4) the latest trends in ICT related to virtual commerce. In the end, the following research gaps were found.

First, the design-factor mapping is largely biased. Figure 10 plotted the occurrence of each boundary factor in behavior papers (tallied from Table 7), design artifacts (tallied from Table 9), and design papers (tallied from both Tables 8 and 9). At one end, 14 design artifacts (53%) and 30 design studies (81%) can be categorized into improving consumer's perceived ease of use. Furthermore, eight design artifacts (30%) and 19 design studies (51%) can be categorized into improving consumer's perceived usability. As perceived system ease of use and usability (or usefulness) are two notable factors of the TAM, it can

be concluded that most design artifacts (85%) and studies (81%) can improve consumer's acceptance of applying immersive technologies to e-commerce. At the other end, many factors have only been studied insufficiently in design papers, including 3D authenticity, control, vividness, spatial presence, layout, and objective interactivity. Moreover, there is no design paper concerning hedonic value.

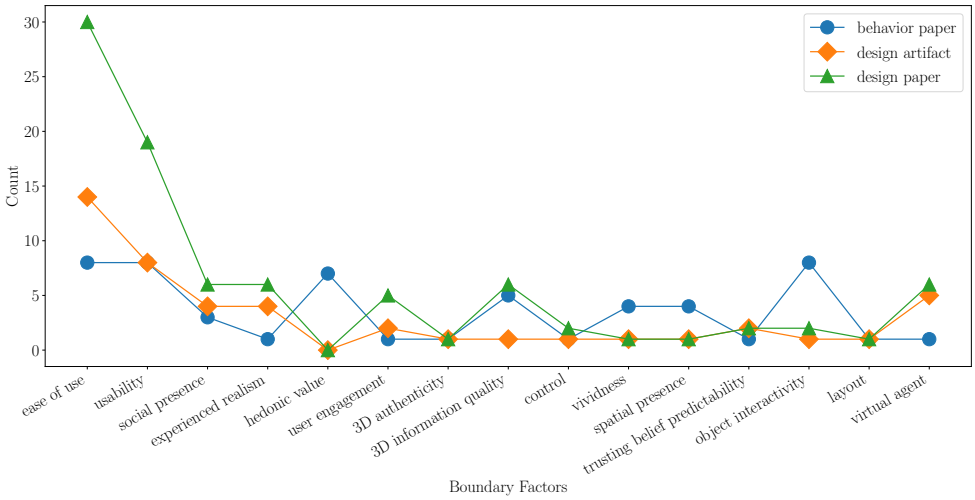

Figure 10. The occurrence of boundary factors in behavior papers, design papers, and design artifacts.

Second, the biased design-factor mapping hints that there could be more unexplored antecedents of purchase intention. One salient factor is customization/personalization, which has been identified as an important determinant of virtual consumption in both game VWs [144] and social VWs [145], as virtual item customization or personalization can enhance an item's hedonic and social value by showing the player's uniqueness [146]. However, this factor has not been covered in the behavioral studies of e-commerce, especially for online retailing. Even so, some designs have already tried to elicit the value of object [132] or environment [137] customization or shopping experience personalization [46,138–140,142], leading to another gap between behavioral and design studies.

Third, variety is absent in the design and factor enhancement related to AR. Most AR design solutions can only improve consumer's perceived ease of use (refer to Table 9) and only one can improve usability [117]. Whether AR can be utilized to enhance other factors has yet to be explored, which is an evident and important gap. From the behavior papers, though five design papers are related to enhancing 3D information quality, they only achieved it through direct product information presentation implemented by AR, while VR-based product presentation has not been discovered within the scope of this paper.

Fourth, MR is seldom utilized in the reviewed papers. In the reviewed papers, AR is sufficient for product display and interaction, thus MR is not needed for complex virtual scenes rendering or virtual object interaction. Furthermore, many AR-related findings are also applicable to MR since they share some common functions. Nonetheless, with the commercialization of MR solutions such as Microsoft's Hololens (https://www.microsoft.com/en-us/hololens, accessed on 16 November 2021), applying MR to virtual commerce can offer innovative retailing and marketing alternatives, igniting relevant research.

Furthermore, regarding virtual consumption, although several behavior papers have emphasized the potential of virtual consumption [41,84,99], there are few design papers covering this topic. From Table 8 , it can be observed that most design artifacts focus on shopping or retailing of real products. Virtual consumption is not identical to real product consumption [42,147], therefore, the validity of those design artifacts intended to enhance the purchase intention of real products needs further evaluation.

Moreover, neither behavior studies nor application designs have constituted a complete research map of virtual commerce within their respective research scope. The behavior studies exclusively focus on the retailing and marketing of products to impact the purchase

intention of individuals. Yet, the manufacturing process can provide a realtime, 3D presentation of a product with IoT [148] and digital twin technology [149], which could promote purchase intention with rich product information [58]. On the other hand, existing design studies mainly used immersive technology to create visually-immersive stimuli such as realistic products and virtual shops, whereas other forms of immersive sensory inputs are seldom explored.

Finally, behavior research communities and application design communities lack the synergy in virtual commerce research. Their contributions to virtual commerce almost remain independent, although few researchers have attempted an iterative behavior-design cycle in developing virtual commerce applications [130,136]. Yet, as advocated by [17], an organic cooperation between design science and behavior science is extremely beneficial.

4.6. Discussion on Future Research Avenues

Based on the identified research gaps, we recommend five research avenues, which are also summarized in Figure 11.

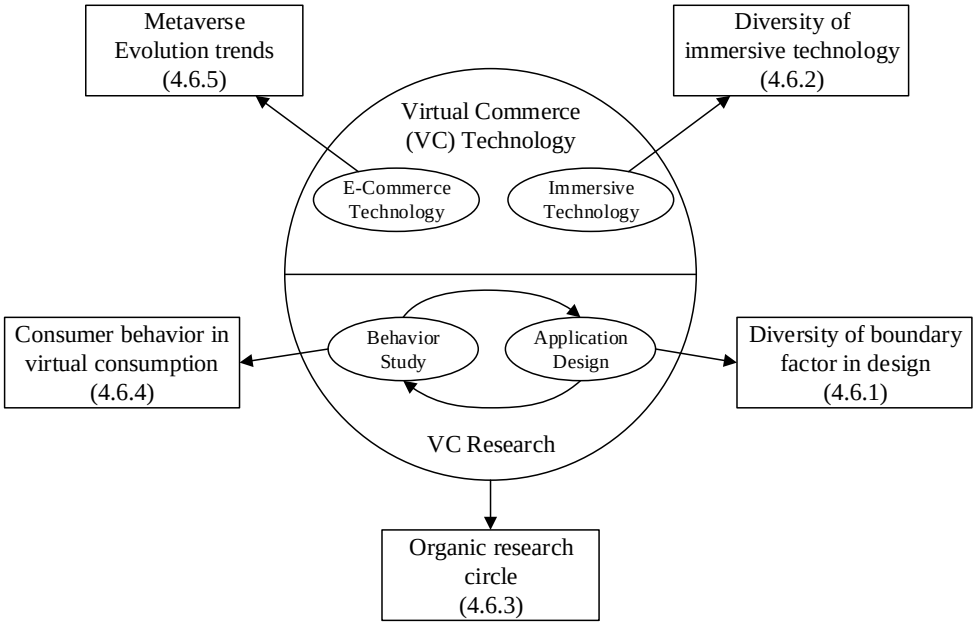

Figure 11. Research gaps and future research directions.

4.6.1. Investigation on the Diversity of Boundary Factors

The diversity of boundary factors can be explored in at least two directions. On the one hand, design papers can extend their concentration to boundary factors other than ease of use and usability as listed in Table 7. Although other factors are addressed in the design papers, such as telepresence and trust [130,136], the coverage rate is relatively low, as illustrated in Figure 10. Therefore, more consideration of them may be necessary. On the other hand, unrevealed factors can be investigated. For instance, the phenomenon of prosumption may worth investigating, which describes an individual being both a consumer and producer of particular products [150–152]. In the context of virtual commerce, a notable example is the creation and sale of virtual products in online games and social VWs (e.g., Second Life). The factors related to this phenomenon can be studied from both consumer psychological study and technical support, such as through employing a digital model, or even a digital twin during the process of design and production of certain products to achieve commodity personalization and customization [153].

4.6.2. Investigation on the Diversity of Immersive Technology

From the systematic review, we observe that the adoption of immersive technology almost exclusively emphasized visual immersion, even though immersive technology encompasses multiple sensory modalities such as visual, auditory, haptic, olfactory, and gustatory [23,154]. While the existing literature has proven the effectiveness of visual stimuli on creating immersive experience, it is intriguing to investigate whether and how other sensory information affects a user's immersion state and impacts their consumption behavior. In addition, MR techniques such as holographic have not gained sufficient attention, yet it is worth studying whether it will trigger consumer responses similar to existing AR/VR/VW applications once it is ready for commercial use. Moreover, researchers can study the methodologies to organically integrate multiple sources of sensory information when designing the immersive virtual environment for a virtual commerce application. Finally, researchers should be aware of technology evolutions and their potential value-added toward virtual commerce, including maturing MR products and emerging immersive technology. For example, the launch of Neuralink in 2020 (https://neuralink.com/about/, accessed on 16 November 2021) has raised awareness of brain–computer interfaces. This interface utilizes a user's neural oscillations (or brainwaves) as a type of sensory information to interact with the physical world. Considering that navigability can impact ease of use and usability according to Table 9, researchers may be curious whether brainwaves input can achieve more efficient navigation in the immersive virtual environment of a virtual commerce application.

4.6.3. An Organic Behavior–Design Research Circle

To explore research opportunities concerning a factor, researchers can combine a rigorous behavior analysis with a design study (analyze-then-design paradigm), the former of which can theoretically justify the significance of the discussed problem, while the latter realizes a practical solution to it. Correspondingly, a behavior paper can re-evaluate a proposed behavioral theory by conducting empirical studies considering new designs (re-evaluation paradigm). For example, some previously ignored factors may become outstanding, suggesting the need for a design concentration shift for subsequent research. Furthermore, it may even identify new boundary factors, extending the knowledge base of consumer behavior in virtual commerce. Together, the re-evaluation paradigm and the analyze-then-design paradigm can constitute a research circle that efficiently pushes forward virtual commerce research and applications.

4.6.4. Paying Attention to Virtual Consumption

Consumer behavior researchers should be aware that the theories validated under real-world context may fail to explain consumer behaviors of virtual consumption [147]. Therefore, a fundamental yet essential work is to understand the unique consumer behaviors in virtual consumption. Actually, this can also inspire researchers of application design. Instead of directly enhancing certain consumer behaviors to promote virtual consumption, they may consider designs that can assist the behavioral research, such as the automatic recording and analysis pipelines of user behavior in [18]. These designs can benefit the research community by tremendously reducing the tedious workload of data collection and organization in the research process, allowing the researchers to focus on more intelligence-intensive tasks. Moreover, in VW research, virtual consumption per se is essential toward a sustainable virtual economy [2]. However, such an envision is still a far cry from reality, since a VW infrastructure with sufficient capabilities has yet to be developed [38]. Therefore, application design researchers are encouraged to contribute to the infrastructure design, adding building blocks to the study and comprehension of virtual consumption.

4.6.5. Consideration of Metaverse Evolution Trends

The design artifacts identified in the review (see Table 8) barely cover any general design requirement except for scalability and accessibility of a client. Consequently, researchers should be curious about the roles of general design requirements on consumer behaviors. For example, in terms of VW design, ref. [38] identified the emerging requirements of sufficiency, reliability, persistency, and credibility. Particularly, persistency and credibility can be highly relevant to consumer purchase in a VW. For persistency, user content persistency is directly related to the permanent existence of a user's digital asset in a VW. Presumably, a low level of content persistency can reduce a user's willingness to buy high-value products in a VW. Similar results can be expected with a low level of credibility, which stresses the trust of users on a VW to securely manage and legally protect their data. These hypotheses can be further argued and refined, and then validated (or rejected) through behavioral research. Again, the behavioral research on these topics need help from application design researchers to build the required VW infrastructure.

Furthermore, researchers should investigate how to transform virtual commerce along with a broader definition on Metaverse, which has been perceived as the next-generation of Internet and where interconnected, shared, and persistent 3D virtual spaces co-exist [155,156]. As reflected in the review, immersive technology applied in virtual commerce can sufficiently create the visually immersive virtual spaces for a metaverse. Nevertheless, utilization of other emerging technologies, such as faster communication infrastructures (e.g., 5G), secure distributed ledger (e.g., blockchain), and innovative computing paradigms (e.g., mobile, edge, and cloud computing), is essential to achieve the interconnectivity, persistency, and other features of the metaverse, which is likely to establish a new form of electronic commerce. We tentatively call it meta-commerce.

5. Conclusions

This paper studied the design of virtual commerce applications to promote purchase with a systematic literature review. The contribution of this paper included a conceptual framework considering purchase intention as an outcome, a list of boundary factors identified from behavior papers, a list of design artifacts identified from design papers, the mappings of design and factor that can serve as a reference for virtual commerce system and application design, the research gaps between the two topics of design and consumer behavior, which advocates a synergistic effort in researching virtual commerce. Furthermore, above all, future research directions are suggested, including investigation on the diversity of boundary factors and immersive technology, formation of an organic behavior-design researcher circle, virtual consumption, and Metaverse evolution trends.

To further extend the knowledge obtained in this paper, several aspects can be considered by future researchers. First, the search protocol can be improved. For instance, additional search keywords like "consumption" and "sale" may increase the search accuracy, and adding geographical constraints to the search conditions is more appropriate when studying virtual commerce within a country or region. Second, the conceptual framework of consumer purchase can be synthesized from different angles. This paper only considered constructs directly and positively influencing consumer outcomes. While this infers the design artifacts to improve, analysis of constructs with negative influence may also be valuable to system design, serving as a reminder of what should be avoided. Furthermore, empirical studies can be conducted to achieve a more rigorous consumer behavior model, since in the data synthesis process, inconsistent assumptions in reviewed papers may cause biased results, such as demographic characteristics.

In conclusion, this paper is a novel attempt to aggregate the research on virtual commerce systems from system design and consumer behavior research. In the future, we expect to see more research outcomes after creating such a continuum between behavior analysis and application design.

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References

1. Laudon, K.C.; Traver, C.G. *E-Commerce: Business, Technology, Society*; Pearson: London, UK, 2016.
2. Guo, J.; Gong, Z. Measuring virtual wealth in virtual worlds. *Inf. Technol. Manag.* **2011**, *12*, 121–135. [CrossRef]
3. Kou, W. *Payment Technologies for E-Commerce*; Springer: Berlin/Heidelberg, Germany, 2013.
4. Slater, M.; Wilbur, S. A Framework for Immersive Virtual Environments (FIVE): Speculations on the Role of Presence in Virtual Environments. *Presence Teleoperators Virtual Environ.* **1997**, *6*, 603–616. [CrossRef]
5. Kovács, P.T.; Murray, N.; rozinaj, G.; sulema, Y.; rybárová, R. Application of immersive technologies for education: State of the art. In Proceedings of the 2015 International Conference on Interactive mobile communication technologies and learning (IMCL), Thessaloniki, Greece, 19–20 November 2015; pp. 283–288.
6. Suh, A.; Prophet, J. The state of immersive technology research: A literature analysis. *Comput. Hum. Behav.* **2018**, *86*, 77–90. [CrossRef]
7. Xue, L.; Parker, C.J.; McCormick, H. A virtual reality and retailing literature review: Current focus, underlying themes and future directions. In *Augmented Reality and Virtual Reality*; Springer: Berlin/Heidelberg, Germany, 2019; pp. 27–41.
8. Sensortower. Pokémon GO Hits $1 Billion in 2020 as Lifetime Revenue Surpasses $4 Billion. 2020. Available online: https://sensortower.com/blog/pokemon-go-one-billion-revenue-2020 (accessed on 16 December 2020).
9. MordorIntelligence. Global Virtual Reality In Gaming Market (2020 to 2025)–Growth, Trends, and Forecast. 2020. Available online: https://mordorintelligence.com (accessed on 16 December 2020).
10. Viglialoro, R.M.; Condino, S.; Turini, G.; Carbone, M.; Ferrari, V.; Gesi, M. Augmented Reality, Mixed Reality, and Hybrid Approach in Healthcare Simulation: A Systematic Review. *Appl. Sci.* **2021**, *11*, 2338. [CrossRef]
11. Han, B.; Kim, G.J. AudienceMR: Extending the Local Space for Large-Scale Audience with Mixed Reality for Enhanced Remote Lecturer Experience. *Appl. Sci.* **2021**, *11*, 9022. [CrossRef]
12. Doolani, S.; Owens, L.; Wessels, C.; Makedon, F. vIS: An Immersive Virtual Storytelling System for Vocational Training. *Appl. Sci.* **2020**. *10*, 8143. [CrossRef]
13. Pérez, L.; Rodríguez-Jiménez, S.; Rodríguez, N.; Usamentiaga, R.; García, D.F. Digital Twin and Virtual Reality Based Methodology for Multi-Robot Manufacturing Cell Commissioning. *Appl. Sci.* **2020**. *10*, 3633. [CrossRef]
14. Choi, U.; Choi, B. The Effect of Augmented Reality on Consumer Learning for Search and Experience Products in Mobile Commerce. *Cyberpsychol. Behav. Soc. Netw.* **2020**, *23*, 800–805. [CrossRef]
15. Moriuchi, E.; Landers, V.M.; Colton, D.; Hair, N. Engagement with chatbots versus augmented reality interactive technology in e-commerce. *J. Strateg. Mark.* **2020**, *29*, 375–389. [CrossRef]
16. Scholz, J.; Duffy, K. We ARe at home: How augmented reality reshapes mobile marketing and consumer-brand relationships. *J. Retail. Consum. Serv.* **2018**, *44*, 11–23. [CrossRef]
17. Hevner, A.R.; March, S.T.; Park, J.; Ram, S. Design science in information systems research. *MIS Q.* **2004**, *28* 75–105. [CrossRef]
18. Elboudali, A.; Aoussat, A.; Mantelet, F.; Bethomier, J.; Leray, F. A customised virtual reality shopping experience framework based on consumer behaviour: 3DR3CO. *Int. J. Interact. Des. Manuf. (IJIDeM)* **2020**, *14*, 551–563. [CrossRef]
19. Xue, L.; Parker, C.J.; Hart, C.A. How to Engage Fashion Retail with Virtual Reality: A Consumer Perspective. In *Augmented Reality and Virtual Reality*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 23–35.
20. Cummings, J.J.; Bailenson, J.N. How Immersive Is Enough? A Meta-Analysis of the Effect of Immersive Technology on User Presence. *Media Psychol.* **2015**, *19*, 272–309. [CrossRef]
21. Flavián, C.; Ibáñez-Sánchez, S.; Orús, C. The impact of virtual, augmented and mixed reality technologies on the customer experience. *J. Bus. Res.* **2019**, *100*, 547–560. [CrossRef]
22. Loureiro, S.M.C.; Guerreiro, J.; Eloy, S.; Langaro, D.; Panchapakesan, P. Understanding the use of Virtual Reality in Marketing: A text mining-based review. *J. Bus. Res.* **2019**, *100*, 514–530. [CrossRef]

23. Wedel, M.; Bigné, E.; Zhang, J. Virtual and augmented reality: Advancing research in consumer marketing. *Int. J. Res. Mark.* **2020**, *37*, 443–465. [CrossRef]
24. Kowalczuk, P.; (née Scheiben), C.S.; Adler, J. Cognitive, affective, and behavioral consumer responses to augmented reality in e-commerce: A comparative study. *J. Bus. Res.* **2021**, *124*, 357–373. [CrossRef]
25. Blasco-Arcas, L.; Hernandez-Ortega, B.I.; Jimenez-Martinez, J. Engagement platforms: The role of emotions in fostering customer engagement and brand image in interactive media. *J. Serv. Theory Pract.* **2016**, *26*, 559–589. [CrossRef]
26. Bhattacherjee, A. *Social Science Research: Principles, Methods, and Practices*; Global Text Project; University of South Florida: Tampa, FL, USA, 2012.
27. Milgram, P.; Kishino, F. A taxonomy of mixed reality visual displays. *IEICE Trans. Inf. Syst.* **1994**, *77*, 1321–1329.
28. Mann, S. Mediated reality with implementations for everyday life. *Presence Connect* **2002**, *1*, 2002.
29. Jeon, S.; Choi, S. Haptic Augmented Reality: Taxonomy and an Example of Stiffness Modulation. *Presence Teleoperators Virtual Environ.* **2009**, *18*, 387–408. [CrossRef]
30. Speicher, M.; Hall, B.D.; Nebeling, M. What is Mixed Reality? In Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, Glasgow, UK, 4–9 May 2019. [CrossRef]
31. Azuma, R.T. A survey of augmented reality. *Presence Teleoperators Virtual Environ.* **1997**, *6*, 355–385. [CrossRef]
32. Çöltekin, A.; Lochhead, I.; Madden, M.; Christophe, S.; Devaux, A.; Pettit, C.; Lock, O.; Shukla, S.; Herman, L.; Stachoň, Z.; et al. Extended reality in spatial sciences: A review of research challenges and future directions. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 439. [CrossRef]
33. Vasarainen, M.; Paavola, S.; Vetoshkina, L. A Systematic Literature Review on Extended Reality: Virtual, Augmented and Mixed Reality in Working Life. *Int. J. Virtual Real.* **2021**, *21*, 1–28. [CrossRef]
34. Ryan, M.L. Narrative as virtual reality. *Immersion and Interactivity in Literature*; Johns Hopkins University Press: Baltimore, MD, USA, 2001.
35. Carmigniani, J.; Furht, B.; Anisetti, M.; Ceravolo, P.; Damiani, E.; Ivkovic, M. Augmented reality technologies, systems and applications. *Multimed. Tools Appl.* **2011**, *51*, 341–377. [CrossRef]
36. Papadopoulos, T.; Evangelidis, K.; Kaskalis, T.H.; Evangelidis, G.; Sylaiou, S. Interactions in Augmented and Mixed Reality: An Overview. *Appl. Sci.* **2021**, *11*, 8752. [CrossRef]
37. Nevelsteen, K.J. Virtual world, defined from a technological perspective and applied to video games, mixed reality, and the Metaverse. *Comput. Animat. Virtual Worlds* **2018**, *29*, e1752. [CrossRef]
38. Shen, B.; Tan, W.; Guo, J.; Cai, H.; Wang, B.; Zhuo, S. A Study on Design Requirement Development and Satisfaction for Future Virtual World Systems. *Future Internet* **2020**, *12*, 112. [CrossRef]
39. Sherman, W.R.; Craig, A.B. *Understanding Virtual Reality*; Morgan Kauffman: San Francisco, CA, USA, 2003.
40. Jin, S.A.A.; Bolebruch, J. Virtual commerce (V-Commerce) in second life: The roles of physical presence and brand-self connection. *J. Virtual Worlds Res.* **2010**, *2*, 1–12. [CrossRef]
41. Animesh, A.; Pinsonneault, A.; Yang, S.B.; Oh, W. An odyssey into virtual worlds: Exploring the impacts of technological and spatial environments on intention to purchase virtual products. *Mis Q.* **2011**, *35*, 789–810. [CrossRef]
42. Denegri-Knott, J.; Molesworth, M. Concepts and practices of digital virtual consumption. *Consum. Mark. Cult.* **2010**, *13*, 109–132. [CrossRef]
43. Arakji, R.Y.; Lang, K.R. Avatar business value analysis: A method for the evaluation of business value creation in virtual commerce. *J. Econ. Commer. Res.* **2008**, *9*, 207–218.
44. Papagiannidis, S.; Pantano, E.; See-To, E.W.; Bourlakis, M. Modelling the determinants of a simulated experience in a virtual retail store and users' product purchasing intentions. *J. Mark. Manag.* **2013**, *29*, 1462–1492. [CrossRef]
45. Scarle, S.; Arnab, S.; Dunwell, I.; Petridis, P.; Protopsaltis, A.; de Freitas, S. E-commerce transactions in a virtual environment: Virtual transactions. *Electron. Commer. Res.* **2012**, *12*, 379–407. [CrossRef]
46. Shen, X.; Radakrishnan, T.; Georganas, N.D. vCOM: Electronic commerce in a collaborative virtual world. *Electron. Commer. Res. Appl.* **2002**, *1*, 281–300. [CrossRef]
47. Protopsaltou, D.; Luible, C.; Arevalo, M.; Magnenat-Thalmann, N. A body and garment creation method for an Internet based virtual fitting room. In *Advances in Modelling, Animation and Rendering*; Springer: Berlin/Heidelberg, Germany, 2002; pp. 105–122.
48. Verhulst, A.; Normand, J.M.; Lombart, C.; Moreau, G. A study on the use of an immersive virtual reality store to investigate consumer perceptions and purchase behavior toward non-standard fruits and vegetables. In Proceedings of the 2017 IEEE Virtual Reality (VR), Los Angeles, CA, USA, 18–22 March 2017; pp. 55–63.
49. Martínez-Navarro, J.; Bigné, E.; Guixeres, J.; Alcañiz, M.; Torrecilla, C. The influence of virtual reality in e-commerce. *J. Bus. Res.* **2019**, *100*, 475–482. [CrossRef]
50. Beck, M.; Crié, D. I virtually try it… I want it! Virtual Fitting Room: A tool to increase on-line and off-line exploratory behavior, patronage and purchase intentions. *J. Retail. Consum. Serv.* **2018**, *40*, 279–286. [CrossRef]
51. Qin, P.; Guo, J. A novel machine natural language mediation for semantic document exchange in smart city. *Future Gener. Comput. Syst.* **2020**, *102*, 810–826. [CrossRef]
52. Xi, N.; Hamari, J. Shopping in virtual reality: A literature review and future agenda. *J. Bus. Res.* **2021**, *134*, 37–58. [CrossRef]
53. Karimi, S. A Purchase Decision-Making Process Model of Online Consumers and Its Influential Factora Cross Sector Analysis. Ph.D. Thesis, The University of Manchester, Manchester, UK, 2013.

54. Zhang, K.Z.; Benyoucef, M. Consumer behavior in social commerce: A literature review. *Decis. Support Syst.* **2016**, *86*, 95–108. [CrossRef]
55. Kardes, F.R.; Cline, T.W.; Cronley, M.L. *Consumer Behavior: Science and Practice*; South-Western Cengage Learning: Florence, SC, USA, 2011.
56. Morrison, D.G. Purchase intentions and purchase behavior. *J. Mark.* **1979**, *43*, 65–74. [CrossRef]
57. Ajzen, I. From intentions to actions: A theory of planned behavior. In *Action Control*; Springer: Berlin/Heidelberg, Germany, 1985; pp. 11–39.
58. Chang, T.Z.; Wildt, A.R. Price, product information, and purchase intention: An empirical study. *J. Acad. Mark. Sci.* **1994**, *22*, 16–27. [CrossRef]
59. Chang, H.H.; Chen, S.W. The impact of online store environment cues on purchase intention. *Online Inf. Rev.* **2008**, *32*, 818–841. [CrossRef]
60. Mirabi, V.; Akbariyeh, H.; Tahmasebifard, H. A study of factors affecting on customers purchase intention. *J. Multidiscip. Eng. Sci. Technol. (JMEST)* **2015**, *2*, 267–273.
61. Jacoby, J. Stimulus-organism-response reconsidered: An evolutionary step in modeling (consumer) behavior. *J. Consum. Psychol.* **2002**, *12*, 51–57. [CrossRef]
62. Kim, M.J.; Lee, C.K.; Jung, T. Exploring consumer behavior in virtual reality tourism using an extended stimulus-organism-response model. *J. Travel Res.* **2020**, *59*, 69–89. [CrossRef]
63. Laato, S.; Islam, A.N.; Farooq, A.; Dhir, A. Unusual purchasing behavior during the early stages of the COVID-19 pandemic: The stimulus-organism-response approach. *J. Retail. Consum. Serv.* **2020**, *57*, 102224. [CrossRef]
64. Chang, H.J.; Eckman, M.; Yan, R.N. Application of the Stimulus-Organism-Response model to the retail environment: The role of hedonic motivation in impulse buying behavior. *Int. Rev. Retail. Distrib. Consum. Res.* **2011**, *21*, 233–249. [CrossRef]
65. Chen, C.C.; Yao, J.Y. What drives impulse buying behaviors in a mobile auction? The perspective of the Stimulus-Organism-Response model. *Telemat. Inform.* **2018**, *35*, 1249–1262. [CrossRef]
66. Moghaddasi, M.; Marín-Morales, J.; Khatri, J.; Guixeres, J.; Giglioli, I.A.C.; Alcañiz, M. Recognition of Customers' Impulsivity from Behavioral Patterns in Virtual Reality. *Appl. Sci.* **2021**, *11*, 4399. [CrossRef]
67. Sandhusen, R. *Marketing*; Barrons: Hauppauge, NY, USA, 2008.
68. Borden, N.H. The concept of the marketing mix. *J. Advert. Res.* **1964**, *4*, 2–7.
69. Duncan, R.B. Characteristics of organizational environments and perceived environmental uncertainty. *Adm. Sci. Q.* **1972**, *17*, 313–327. [CrossRef]
70. Yung, R.; Khoo-Lattimore, C. New realities: A systematic literature review on virtual reality and augmented reality in tourism research. *Curr. Issues Tour.* **2019**, *22*, 2056–2081. [CrossRef]
71. Akter, S.; Wamba, S.F. Big data analytics in E-commerce: A systematic review and agenda for future research. *Electron. Mark.* **2016**, *26*, 173–194. [CrossRef]
72. Busalim, A.H. Understanding social commerce: A systematic literature review and directions for further research. *Int. J. Inf. Manag.* **2016**, *36*, 1075–1088. [CrossRef]
73. Kitchenham, B.; Charters, S. *Guidelines for Performing Systematic Literature Reviews in Software Engineering*; Technical Report, Ver. 2.3 EBSE Technical Report; EBSE: Durham, UK, 2007.
74. Webster, J.; Watson, R.T. Analyzing the past to prepare for the future: Writing a literature review. *MIS Q.* **2002**, *26*,13–23.
75. Papagiannidis, S.; Pantano, E.; See-To, E.W.; Dennis, C.; Bourlakis, M. To immerse or not? Experimenting with two virtual retail environments. *Inf. Technol. People* **2017**, *30*, 163–188. [CrossRef]
76. Lee, K.C.; Chung, N. Empirical analysis of consumer reaction to the virtual reality shopping mall. *Comput. Hum. Behav.* **2008**, *24*, 88–104. [CrossRef]
77. Goel, L.; Prokopec, S. If you build it will they come?—An empirical investigation of consumer perceptions and strategy in virtual worlds. *Electron. Commer. Res.* **2009**, *9*, 115–134. [CrossRef]
78. Krasonikolakis, I.; Vrechopoulos, A.; Pouloudi, A.; Dimitriadis, S. Store layout effects on consumer behavior in 3D online stores. *Eur. J. Mark.* **2018**, *52*, 1223-1256. [CrossRef]
79. Pantano, E.; Servidio, R. Modeling innovative points of sales through virtual and immersive technologies. *J. Retail. Consum. Serv.* **2012**, *19*, 279–286. [CrossRef]
80. Oh, H.; Yoon, S.Y.; Shyu, C.R. How can virtual reality reshape furniture retailing? *Cloth. Text. Res. J.* **2008**, *26*, 143–163. [CrossRef]
81. Baker, E.W.; Hubona, G.S.; Srite, M. Does "Being There" Matter? The Impact of Web-Based and Virtual World's Shopping Experiences on Consumer Purchase Attitudes. *Inf. Manag.* **2019**, *56*, 103153. [CrossRef]
82. Teoh, K.K.; Cyril, E.U. The role of presence and para social presence on trust in online virtual electronic commerce. *J. Appl. Sci.* **2008**, *8*, 2834–2842. [CrossRef]
83. Tran, M.Q.; Minocha, S.; Roberts, D.; Laing, A.; Langdridge, D. A Means-End Analysis of Consumers' Perceptions of Virtual World Affordances for E-commerce. In *IFIP Conference on Human–Computer Interaction*; Springer: Berlin/Heidelberg, Germany, 2011; pp. 362–379.
84. Jung, Y.; Pawlowski, S.D. Virtual goods, real goals: Exploring means-end goal structures of consumers in social virtual worlds. *Inf. Manag.* **2014**, *51*, 520–531. [CrossRef]

85. Lau, K.W.; Lee, P.Y. Shopping in virtual reality: A study on consumers' shopping experience in a stereoscopic virtual reality. *Virtual Real.* **2019**, *23*, 255–268. [CrossRef]
86. Jin, S.A.A. The roles of modality richness and involvement in shopping behavior in 3D virtual stores. *J. Interact. Mark.* **2009**, *23*, 234–246. [CrossRef]
87. Schlosser, A.E. Experiencing products in the virtual world: The role of goal and imagery in influencing attitudes versus purchase intentions. *J. Consum. Res.* **2003**, *30*, 184–198. [CrossRef]
88. Algharabat, R.; Alalwan, A.A.; Rana, N.P.; Dwivedi, Y.K. Three dimensional product presentation quality antecedents and their consequences for online retailers: The moderating role of virtual product experience. *J. Retail. Consum. Serv.* **2017**, *36*, 203–217. [CrossRef]
89. Park, J.; Choi, J.; Rhee, C. Futuristic VR image presentation technique for better mobile commerce effectiveness. *Virtual Real.* **2020**, *25*, 1–16. [CrossRef]
90. Ramirez, A., Jr.; Burgoon, J.K. The effect of interactivity on initial interactions: The influence of information valence and modality and information richness on computer-mediated interaction. *Commun. Monogr.* **2004**, *71*, 422–447. [CrossRef]
91. Burgoon, J.K.; Bonito, J.A.; Ramirez, A., Jr.; Dunbar, N.E.; Kam, K.; Fischer, J. Testing the interactivity principle: Effects of mediation, propinquity, and verbal and nonverbal modalities in interpersonal interaction. *J. Commun.* **2002**, *52*, 657–677. [CrossRef]
92. Yim, M.Y.C.; Chu, S.C.; Sauer, P.L. Is augmented reality technology an effective tool for e-commerce? An interactivity and vividness perspective. *J. Interact. Mark.* **2017**, *39*, 89–103. [CrossRef]
93. Rese, A.; Baier, D.; Geyer-Schulz, A.; Schreiber, S. How augmented reality apps are accepted by consumers: A comparative analysis using scales and opinions. *Technol. Forecast. Soc. Chang.* **2017**, *124*, 306–319. [CrossRef]
94. Plotkina, D.; Saurel, H. Me or just like me? The role of virtual try-on and physical appearance in apparel M-retailing. *J. Retail. Consum. Serv.* **2019**, *51*, 362–377. [CrossRef]
95. Kim, J.; Forsythe, S. Adoption of virtual try-on technology for online apparel shopping. *J. Interact. Mark.* **2008**, *22*, 45–59. [CrossRef]
96. Park, S.; Fui-Hoon Nah, F.; DeWester, D.; Eschenbrenner, B.; Jeon, S. Virtual world affordances: Enhancing brand value. *J. Virtual Worlds Res.* **2008**, *1*, 38. [CrossRef]
97. Mackenzie, K.; Buckby, S.; Irvine, H. A framework for evaluating business lead users' virtual reality innovations in Second Life. *Electron. Commer. Res.* **2009**, *9*, 183–202. [CrossRef]
98. Li, H.; Daugherty, T.; Biocca, F. The role of virtual experience in consumer learning. *J. Consum. Psychol.* **2003**, *13*, 395–407. [CrossRef]
99. Cheon, E. Energizing business transactions in virtual worlds: An empirical study of consumers' purchasing behaviors. *Inf. Technol. Manag.* **2013**, *14*, 315–330. [CrossRef]
100. Cobb-Walgren, C.J.; Ruble, C.A.; Donthu, N. Brand equity, brand preference, and purchase intent. *J. Advert.* **1995**, *24*, 25–40. [CrossRef]
101. Farquhar, P.H. Managing brand equity. *Mark. Res.* **1989**, *1*, 24–33.
102. Nakamura, J.; Csikszentmihalyi, M. The concept of flow. In *Flow and the Foundations of Positive Psychology*; Springer: Dordrecht, The Netherlands, 2014; pp. 239–263.
103. Ghani, J.A.; Supnick, R.; Rooney, P. The Experience of Flow in Computer-mediated and in Face-to-face Groups. *ICIS* **1991**, *91*, 229–237.
104. Merle, A.; Senecal, S.; St-Onge, A. Whether and how virtual try-on influences consumer responses to an apparel web site. *Int. J. Electron. Commer.* **2012**, *16*, 41–64. [CrossRef]
105. de Vries, R.; Jager, G.; Tijssen, I.; Zandstra, E.H. Shopping for products in a virtual world: Why haptics and visuals are equally important in shaping consumer perceptions and attitudes. *Food Qual. Prefer.* **2018**, *66*, 64–75. [CrossRef]
106. Cowan, K.; Ketron, S. A dual model of product involvement for effective virtual reality: The roles of imagination, co-creation, telepresence, and interactivity. *J. Bus. Res.* **2019**, *100*, 483–492. [CrossRef]
107. Li, H.; Daugherty, T.; Biocca, F. Impact of 3-D advertising on product knowledge, brand attitude, and purchase intention: The mediating role of presence. *J. Advert.* **2002**, *31*, 43–57. [CrossRef]
108. Papagiannidis, S.; Bourlakis, M.; Li, F. Making real money in virtual worlds: MMORPGs and emerging business opportunities, challenges and ethical implications in metaverses. *Technol. Forecast. Soc. Chang.* **2008**, *75*, 610–622. [CrossRef]
109. Liu, S.F.; Lee, M.H. Mobile Commerce System Integrated with Augmented Reality and Interactive Multimedia. *Przegląd Elektrotechniczny* **2012**, *88*, 100–103.
110. Park, J.; Lee, W. Augmented E-commerce: Making augmented reality usable in everyday E-commerce with laser projection tracking. In *International Workshop on Multimedia Interactive Protocols and Systems*; Springer: Grenoble, France, 2004; pp. 242–251.
111. Kim, T.; Park, J. LasAR: Laser Pointer Based Mobile Augmented Reality for E-Commerce Services. In *International Conference on Hybrid Information Technology*; Springer: Daejeon, Korea, 2012; pp. 333–341.
112. Li, X.; Chen, D. Registration Correction for Augmented Reality in E-Commerce. In Proceedings of the 2009 International Conference on Management and Service Science, Beijing, China, 20–22 September 2009; pp. 1–4.

113. Welivita, A.; Nimalsiri, N.; Wickramasinghe, R.; Pathirana, U.; Gamage, C. Virtual Product Try-On Solution for E-Commerce Using Mobile Augmented Reality. In *International Conference on Augmented Reality, Virtual Reality and Computer Graphics*; Springer: Ugento, Italy, 2017; pp. 438–447.
114. Lu, Y.; Smith, S. Augmented reality e-commerce assistant system: Trying while shopping. In *International Conference on Human–Computer Interaction*; Springer: Beijing, China, 2007; pp. 643–652.
115. Zhang, B. Augmented reality virtual glasses try-on technology based on iOS platform. *EURASIP J. Image Video Process.* **2018**, *2018*, 132. [CrossRef]
116. Hsieh, M.Y.; Lin, H.Y.; Weng, T.H. A Virtual Interactive System for Merchandising Stores. In *International Conference on Frontier Computing*; Springer: Kuala Lumpur, Malaysia, 2018; pp. 266–277.
117. Pereira, F.; Silva, C.; Alves, M. Virtual fitting room augmented reality techniques for e-commerce. In Proceedings of the International Conference on ENTERprise Information Systems, Algarve, Portugal, 5–7 October 2011; pp. 62–71.
118. Gallardo, C.; Rodríguez, S.P.; Chango, I.E.; Quevedo, W.X.; Santana, J.; Acosta, A.G.; Tapia, J.C.; Andaluz, V.H. Augmented Reality as a New Marketing Strategy. In Proceedings of the International Conference on Augmented Reality, Virtual Reality and Computer Graphics, Otranto, Italy, 24–27 June 2018; pp. 351–362.
119. Cruz, E.; Orts-Escolano, S.; Gomez-Donoso, F.; Rizo, C.; Rangel, J.C.; Mora, H.; Cazorla, M. An augmented reality application for improving shopping experience in large retail stores. *Virtual Real.* **2019**, *23*, 281–291. [CrossRef]
120. Bogdanovych, A.; Berger, H.; Simoff, S.J.; Sierra, C. E-commerce environments as 3d electronic institutions. In Proceedings of the IADIS International Conference on e-Commerce, Lisbon, Portugal, 26–28 May 2004; Springer: Xiamen, China, 2004; pp. 309–318.
121. Ye, L.; Xu, B.; Ji, Q.; Pan, Z.; Yang, H. Design and implementation of a collaborative virtual shopping system. In Proceedings of the International Conference on Computer Supported Cooperative Work in Design, Xiamen, China, 26–28 May 2004; Springer: Xiamen, China, 2004; pp. 309–318.
122. Debenham, J.; Simoff, S. An e-market framework for informed trading. In Proceedings of the 15th International Conference on World Wide Web, Edinburgh, UK, 23–26 May 2006 2006; pp. 651–658.
123. Elordi, U.; Segura, A.; Goenetxea, J.; Moreno, A.; Arambarri, J. Virtual Reality Interfaces Applied to Web-Based 3D E-Commerce. In *Engineering Systems Design and Analysis*; American Society of Mechanical Engineers: Nantes, France, 2012; Volume 44847, pp. 341–350.
124. Han, S.; Lim, M.; Lee, D.; Kim, H.; Koo, B.; Kim, S.; Choi, B.T. Scalable network support for 3D virtual shopping mall. In Proceedings of the International Conference on Virtual Systems and Multimedia, Gyeongju Korea, 25–27 September 2002; pp. 336–345.
125. Oliveira, J.C.; Shen, X.; Georganas, N.D. Collaborative virtual environment for industrial training and e-commerce. *IEEE VRTS* **2000**, *288*. AVailable online: https://www.researchgate.net/publication/228691554_Collaborative_Virtual_Environments_for_Industrial_Training_and_e-Commerce (accessed on 16 November 2021).
126. Huang, Y.C.; Liu, S.Y. Virtual Reality Online Shopping (VROS) Platform. In *Proceedings of the International Conference on Human–Computer Interaction*; Springer: Copenhagen, Denmark, 2020; pp. 339–353.
127. Li, Z.; Ma, R.; Obuchi, K.; Liu, B.; Cheng, K.; Masuko, S.; Tanaka, J. Augmented Reality Shopping System Through Image Search and Virtual Shop Generation. In *Proceedings of the International Conference on Human–Computer Interaction*; Springer: Copenhagen, Denmark, 2020; pp. 363–376.
128. Fang, Z.C.; Cai, H. Designing social commerce experience in 3D virtual world. In Proceedings of the 2009 IEEE Conference on Commerce and Enterprise Computing, Vienna, Austria, 20–23 July 2009; pp. 273–278.
129. Mass, Y.; Herzberg, A. VRCommerce—Electronic commerce in virtual reality. In Proceedings of the 1st ACM Conference on Electronic Commerce, Denver, CO, USA, 3–5 November 1999; pp. 103–109.
130. Speicher, M.; Cucerca, S.; Krüger, A. VRShop: A mobile interactive virtual reality shopping environment combining the benefits of on-and offline shopping. *Proc. ACM Interact. Mobile Wearable Ubiquitous Technol.* **2017**, *1*, 1–31. [CrossRef]
131. Ketoma, V.K.; Schäfer, P.; Meixner, G. Development and evaluation of a virtual reality grocery shopping application using a multi-Kinect walking-in-place approach. In *International Conference on Intelligent Human Systems Integration*; Springer: Dubai, United Arab Emirates, 2018; pp. 368–374.
132. Yen, B.C.; Ng, K.Y. Web-based virtual reality catalog in electronic commerce. In Proceedings of the 33rd Annual Hawaii International Conference on System Sciences, Maui, HI, USA, 7 January 2000; p. 10.
133. Paquet, E.; Viktor, H.; Peters, S. The Virtual Boutique: A Synergic Approach to Virtualization, Content-based Management of 3D Information, 3D Data Mining an Virtual Reality for E-commerce. In Proceedings of the 3D Data Processing Visualization and Transmission, International Symposium on IEEE Computer Society, Padova, Italy, 19–21 June 2002; pp. 268–276.
134. De Troyer, O.; Kleinermann, F.; Mansouri, H.; Pellens, B.; Bille, W.; Fomenko, V. Developing semantic VR-shops for e-Commerce. *Virtual Real.* **2007**, *11*, 89–106. [CrossRef]
135. Lee, K.C.; Chung, N. A web DSS approach to building an intelligent internet shopping mall by integrating virtual reality and avatar. *Expert Syst. Appl.* **2005**, *28*, 333–346.
136. Papadopoulou, P. Applying virtual reality for trust-building e-commerce environments. *Virtual Real.* **2007**, *11*, 107–127. [CrossRef]
137. Varlamis, I.; Vazirgiannis, M.; Lazaridis, I.; Papageorgiou, M.; Panayiotopoulos, T. Distributed virtual reality authoring interfaces for the www: The vr-shop case. *Multimed. Tools Appl.* **2004**, *22*, 5–30. [CrossRef]

138. Chittaro, L.; Ranon, R. New directions for the design of virtual reality interfaces to e-commerce sites. In Proceedings of the Working Conference on Advanced Visual Interfaces, Trento, Italy, 22–24 May 2002; pp. 308–315.
139. Chittaro, L.; Ration, R. Adding adaptive features to virtual reality interfaces for e-commerce. In Proceedings of the International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems, Trento, Italy, 28–30 August 2000; pp. 86–97.
140. dos Santos, C.T.; Osorio, F.S. AdapTIVE: An intelligent virtual environment and its application in e-commerce. In Proceedings of the 28th Annual International Computer Software and Applications Conference, COMPSAC 2004, Hong Kong, China, 28–30 September 2004; pp. 468–473.
141. Walczak, K.; Flotyński, J.; Strugała, D. Semantic Contextual Personalization of Virtual Stores. In Proceedings of the International Conference on Augmented Reality, Virtual Reality and Computer Graphics, Santa Maria al Bagno, Italy, 24–27 June 2019; pp. 220–236.
142. Bromuri, S.; Urovi, V.; Contreras, P.; Stathis, K. A virtual e-retailing environment in golem. In Proceedings of the 2008 IET 4th International Conference on Intelligent Environments, Seattle, WA, USA, 21–22 July 2008.
143. Fang, H.; Zhang, J.; Şensoy, M.; Magnenat-Thalmann, N. Reputation mechanism for e-commerce in virtual reality environments. *Electron. Commer. Res. Appl.* **2014**, *13*, 409–422. [CrossRef]
144. Guo, Y.; Barnes, S.J. Explaining purchasing behavior within World of Warcraft. *J. Comput. Inf. Syst.* **2012**, *52*, 18–30.
145. Shelton, A.K. Defining the lines between virtual and real world purchases: Second Life sells, but who's buying? *Comput. Hum. Behav.* **2010**, *26*, 1223–1227. [CrossRef]
146. Lehdonvirta, V. Virtual item sales as a revenue model: Identifying attributes that drive purchase decisions. *Electron. Commer. Res.* **2009**, *9*, 97–113. [CrossRef]
147. Jung, Y.; Pawlowski, S.D. Understanding consumption in social virtual worlds: A sensemaking perspective on the consumption of virtual goods. *J. Bus. Res.* **2014**, *67*, 2231–2238. [CrossRef]
148. Adão, T.; Pinho, T.; Pádua, L.; Magalhães, L.G.; Sousa, J.J.; Peres, E. Prototyping IoT-Based Virtual Environments: An Approach toward the Sustainable Remote Management of Distributed Mulsemedia Setups. *Appl. Sci.* **2021**, *11*, 8854. [CrossRef]
149. Jiang, Z.; Guo, Y.; Wang, Z. Digital twin to improve the virtual-real integration of industrial IoT. *J. Ind. Inf. Integr.* **2021**, *22*, 100196. [CrossRef]
150. Ritzer, G.; Jurgenson, N. Production, consumption, prosumption: The nature of capitalism in the age of the digital 'prosumer'. *J. Consum. Cult.* **2010**, *10*, 13–36. [CrossRef]
151. Andrews, D.L.; Ritzer, G. Sport and prosumption. *J. Consum. Cult.* **2018**, *18*, 356–373. [CrossRef]
152. Bond, A.J.; Widdop, P.; Cockayne, D.; Parnell, D. Prosumption, networks and value during a global pandemic: Lockdown leisure and COVID-19. *Leis. Sci.* **2021**, *43*, 70–77. [CrossRef]
153. Burnett, D.; Thorp, J.; Richards, D.; Gorkovenko, K.; Murray-Rust, D. Digital twins as a resource for design research. In Proceedings of the 8th ACM International Symposium on Pervasive Displays, Palermo, Italy, 12–14 June 2019; pp. 1–2.
154. Toh, W.L.; Bere, M.; Rossell, S.L. Distinguishing multimodal versus multisensory hallucinations in psychosis: Key definitions and a way forward. *Aust. N. Z. J. Psychiatry* **2021**, 00048674211031455. [CrossRef]
155. Nvidia. What Is the Metaverse? 2021. Available online: https://blogs.nvidia.com/blog/2021/08/10/what-is-the-metaverse/ (accessed on 16 September 2021).
156. The Verge. Mark Zuckerberg Is Betting Facebook's Future on the Metaverse. 2021. Available online: https://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview (accessed on 16 September 2021).